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ABSTRACT

This collection of activities uses outdoor education and field trips to teach concepts of multi-disciplinary interest along with lessons in ecology and environment. Teaching modules usually include information on grade level, main subject being addressed, theme, objectives, and other useful information in addition to instructions for the activity. (RE)

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The Prairie--A Resource for Environmental Study

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South central Kansas was once covered with mile upon mile of prairie grassland. Because of the scarcity of trees, this grassy sea was called the "Great American Desert" by early European settlers. But these settlers soon found that, even if there were few trees, there was a rich soil and a climate well suited for the growth of grass. The vast native prairie grassland has been almost entirely replaced by other grasslands of wheat, milo, corn, or with fenced pastures for raising cattle. The importance of these domesticated grasslands as a source of food for our nation and the world is well appreciated. But the significance of the native prairie as our natural heritage is not so widely appreciated. We, at the South-central Kansas Environmental Education Center, have written these curriculum materials in the hope that they will help teachers plan activities that will encourage an appreciation and understanding of the prairie as a natural community and of man's relation to it. A central part of these curriculum materials is a visit to a natural prairie. They have been written particularly for use with field trips to the Sand Prairie Natural History Reservation in Harvey County, Kansas, but can be adapted for use on other prairie natural areas. These curriculum materials particularly focus on the diversity, the interdependence of animals and plants, and the rhythmic patterns in prairie ecosystems. The modules have been written for use in natural science, art, and social science classes.

The general objectives for this set of curriculum materials are:

1. To develop an understanding of certain ecological concepts and of their importance to the structure and function of a prairie ecosystem.
2. To develop an understanding of the process of observation and interpretation of environment both in science and in art.
3. To explore multidisciplinary ramifications of these ecological concepts, particularly those related to the structure and function of human society, the relation of human society to the ecosystems of the earth, and the values of man striving for a quality life.
    a. To understand analogous concepts in the social sciences and the arts.
    b. To look at the effects of human social systems upon the structure and function of natural ecosystems.
4. To develop a sensitivity to and appreciation of a prairie ecosystem both as a biological system and an aesthetic resource.
5. To develop an appreciation for creativity in both science and art.
6. To develop an active concern for conservation of the prairie ecosystem.

These curriculum materials are written in modular form so that you as a teacher can select one or more modules to use to enrich a unit of study. They are written to be used in sequence. Some are designed to introduce

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ideas and concepts and prepare students for a field trip to a prairie. Others describe field activities that can be done on a prairie natural area. And other modules follow up on ideas and concepts explored on the field trip. We have listed some of the sequences that were planned in writing these modules. The ideas introduced in some modules are prerequisites to understanding some of the later modules in the sequence. However, you may want to experiment with using them in other sequences. These materials were not planned as a curriculum in prairie ecology or environmental education, but rather as enrichment materials to be integrated into curriculum units.

These materials have been written for you, the teacher, to use in planning your curriculum. We feel that you can best adapt them for use in your class and prepare handout sheets for or give instructions to your students. We have been rather specific in the description of activities and discussions and have included a brief statement of concepts and a list of references for further reading. However, we encourage you to modify and adapt the activities to best suit your curriculum and your class. We hope you will not use these modules simply as exercises to be gone through step by step with your students, but that you will make them open-ended and exciting experiences. We have included written materials for use by your students in a supplement to the module if we felt this would be helpful.

The age levels for which the modules were planned are indicated on the module. We feel that many modules can be used over a rather wide range of age levels because the activity with some variation can be made understandable and yet challenging for students at different levels of maturity. Teachers of students at the upper or lower ends of this age range will need to modify the module for use with their class. However, we feel that the teacher, with a knowledge of the ability of his/her class, can best make these adaptations. We have included some suggestions for adapting them for older or younger students.

You will find educational objectives listed for each module. We have purposely made these general to incorporate the objectives we had in writing the module. We encourage you, in planning the use of the activities described in the module, to write your own much more specific objectives for the unit and to develop means for evaluating student progress and determining the degree of achievement of the objectives.

Some of the materials needed for activities described in these modules are available on loan from the Southcentral Kansas Environmental Education Center (SKEEC) at Bethel College. Many of the references listed for each module are available in the SKEEC library. SKEEC personnel are available for consultation in the use of these materials. Bethel College students may be available for help with implementing these modules, particularly to help on field trips where the class needs to be divided into smaller groups, each with a leader. However, arrangements for assistance need to be made in advance. For assistance from SKEEC, contact:

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Services by SKEEC are available free or at a minimal cost to SKEEC members. Fees are charged for many services to non-members.

These curriculum materials have been written by the following persons associated with SKEEC:

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We hope these materials will be of use to you in planning units in environmental education. We would like to hear from you and to receive suggestions for the improvement of these materials. We would like to know what worked well and what was difficult to use. We would like to learn of modifications or additions that you made to the activities in the modules. We will appreciate any help you can give us in making these materials more useful and effective in education for an appreciation and understanding of the prairie.

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Index

NOTE: Under Sequence, "Pre" indicates modules to be used in preparing for field trips, "FT" indicates modules that describe field trip activities, and "Post" indicates modules that can be used following a field trip.

Module no.	Title	Sequence	Subject	Age level
1	Diversity--its meaning and relevance in nature	Pre	Biology	Elementary to high school
2	The components of diversity	Pre	Biology	High school
3	Let's study an insect	Pre	Biology	Junior high and high school
4	A shortcut to identification, the taxonomic or dichotomous key	Pre	Biology	Upper elementary to high school
5	The web of interdependence	Pre	Biology	Elementary
6	Interdependence in an ecosystem	Pre	Biology	Junior high and high school
7	Rhythms in nature	Pre	Biology	Elementary
8	The beat of nature	Pre	Biology	High school
9	Understanding structural diversity	Pre	Art	Junior high
10	What is rhythm?	Pre	Art	Junior high
11	Sand Prairie Natural History Reservation	Pre	Biology	All age levels
12	My response to the prairie	FT		All age levels
13	Subdividing space in an ecosystem promotes species diversity	FT	Biology	Upper elementary to high school
14	Circadian or diurnal rhythms	FT	Biology	Upper elementary
15	A study of interdependence at a flower	FT	Biology	Upper elementary
16	A study of the insect visitors to different kinds of flowers	FT	Biology	High school
17	Bird homes	FT	Biology	Junior high

Module no.	Title	Sequence	Subject	Age level
18	Is there a pattern in the distribution of plants in a prairie?	FT	Biology	High school
19	What do grasshoppers eat?	FT	Biology	High school
20	Why is it colored orange?	FT	Biology	Upper elementary and junior high
21	Small vertebrates of the prairie	FT	Biology	All age levels
22	What good is a weed?	FT	Biology	Junior high and high school
23	Comparing two vegetated areas	FT	Biology	High school
24	What's on my plot?	FT	Biology	Elementary and junior high
25	Detective work in a prairie	FT	Biology	Elementary and junior high
26	A clue chart for grasses	FT	Biology	Upper elementary to high school
27	Recycling in a prairie	FT	Biology	Elementary
28	Seasonal rhythms in a prairie	FT	Biology	Junior high and high school
29	Discovering structural diversity	FT	Art	Junior high
30	Seeing the rhythms of the prairie	FT	Art	Junior high
31	What causes rhythmic sleep movements in plants?	Post	Biology	Upper elementary
32	An experiment to determine what grasshoppers eat	Post	Biology	High school
33	How do grasses survive in a prairie?	Post	Biology	Upper elementary and junior high
34	Experimenting with color signals	Post	Biology	Upper elementary and junior high
35	Illustrating roles in the food web and the importance of diversity	Post	Biology	Elementary to high school

Module no.	Title	Sequence	Subject	Age level
36	Some prairie animals that lost out	Post	Biology	Elementary to high school
37	Management of grasslands--decreasers, increasers, invaders	Post	Biology	High school
38	Habitats for wildlife	Post	Biology	Junior high and high school
39	What good is it?	Post	Biology	Elementary to high school
40	Seasonal rhythms and seeds	Post	Biology	High school
41	Growing prairie plants	Post	Biology	Junior high and high school
42	A study of garbage	Post	Biology	Elementary and junior high
43	Preservation of a sample of the prairie ecosystem	Post	Biology and social science	High school
44	Creating structural patterns	Post	Art	Junior high
45	Expressing the rhythms of the prairie	Post	Art	Junior high
46	The radial effects of social events	Post	Social science	High school
47	Cyclical and rhythmic nature of social phenomena	Post	Social science	High school
48	Similarity and diversity in social institutions and events	Post	Social science	High school
49	Interdependency and formal role networks	Post	Social science	High school
50	Interdependency and informal role networks	Post	Social science	High school
51	The individual, institutions, and social structure	Post	Social science	High school
52	The unity of man and his environment	Post	Social science	High school
53	Differential use of land by different social groups	Post	Social science	High school

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Some Suggested Sequences for Use of Modules

These curriculum modules were written to be used in sequence, with modules used in preparation for and follow-up of a module with field trip activities. Some sequences are listed below. The subject of the field trip module is indicated at the left of each sequence and the number of the field trip module is underlined. The preparatory modules are listed in sequence from the left. Those in parentheses are not required in order to do the field trip activities, but would provide additional relevant enrichment. Other preparatory modules should normally be used unless students already are acquainted with the ideas and/or techniques introduced. Relevant follow-up modules are listed to the right of the field trip module. These are not listed in sequence; however, those planned to immediately follow the field trip module are preceded by a dash and immediately follow the field trip module. One or more of those modules separated by commas can be added in a sequence planned by the teacher. Teachers are also encouraged to experiment with these modules in different sequences and to adapt some sequences to different age levels.

High school social science teachers who wish to use an experience in a prairie community as a preparation for some of the social science modules (46 to 53) may want to modify and shorten the preparatory sequence of modules. Junior high art teachers will find two sequences prepared for them and these might be modified for other age levels.

Module 12 can be used in any of these sequences as a first experience in the prairie or to focus on observation and appreciation of the prairie or can be used by itself for a single experience in the prairie.

Key

13	module numbers underlined are field trip modules
(11)	module numbers in parentheses are modules that are not necessary for the teaching sequence
-	modules separated by dashes are normally done in sequence
,	the teacher can select from follow-up modules separated by commas

Modules for Elementary Grades

Diversity

Subdividing and sharing space: 1 - 5 - 11 - 13, 35, 36, 38, 39
Small vertebrates: 1 - 5 - 11 - 21, 35, 36, 38, 39
What's on my plot: 1 - (11) - 24, 33
Grass clue chart: 1 - 11 - 26 - 33

Interdependence

Interdependence at a flower: 5 - 4 - 15, 35, 36, 38, 39
Orange color signals: 5 - 20 - 34, 36, 39
Small vertebrates: 5 - 11 - 21, 35, 36, 38, 39
Detective work: 5 - 11 - 25, 35, 36, 38, 39

Rhythms

Circadian rhythms: 7 - 14 - 31
Recycling: 7 - 11 - 27 - 42, 35

Modules for Junior High

Diversity

Subdividing and sharing space: 1 - 6 - 11 - 13, 35, 36, 37, 38, 39

Small vertebrates: 1 - 6 - 11 - 21, 35, 36, 37, 38, 39

What's on my plot: 1 - 11 - 24, 33, 37, 41

Grass clue chart: 1 - 11 - (9) - 26 - 33, 37, 41

Discovering structural diversity (Art): 9 - (1) - (11) - 29 - 44, 48

Interdependence

Bird homes: 6 - 4 - 17, 36, 38, 39

Orange color signals: 6 - 20 - 34, 36, 38, 39

Small vertebrates: 6 - 11 - 21, 35, 36, 37, 38, 39

Weeds: 6 - 22, 33, 37, 41

Detective work: 6 - 11 - 25, 36, 38, 39

Rhythms

Seasonal rhythms: 8 - 11 - (10) - 28, 33, 40, 41

Prairie rhythms (Art): 10 - (8) - (11) - 30 - 45, 47

Modules for High School

Diversity

Subdividing and sharing space: 1 - (2) - 6 - 3 - 4 - 11 - 13, 35, 36, 37, 38, 39, 43, 48, 49, 50, 51, 52, 53

Plant distribution: 1 - 2 - 11 - 18, 37, 41, 43, 48, 49, 50, 51, 52, 53

Food of grasshoppers: 1 - 2 - 6 - 11 - 19 - 32, 35, 36, 38, 39, 43, 48, 49, 50, 51, 52, 53

Small vertebrates: 1 - 6 - 11 - 21, 35, 36, 37, 38, 39, 43, 48, 49, 50, 51, 52, 53

Vegetative comparisons: 1 - 2 - 23, 33, 37, 41, 43, 48, 49, 50, 51, 52, 53

Grass clue chart: 1 - 11 - (9) - 26 - 33, 37, 41, 43, 48, 49, 50, 51, 52, 53

Interdependence

Insects and flowers: 6 - 3 - 4 - (11) - 16, 35, 36, 38, 39, 43, 46, 49, 50, 51, 52, 53

Small vertebrates: 6 - 11 - 21, 35, 36, 37, 38, 39, 43, 46, 49, 50, 51, 52, 53

Weeds: 6 - 22, 33, 37, 41, 46, 49, 50, 51, 52, 53

Rhythms

Seasonal rhythms: 8 - 11 - (10) - 28 - 40, 33, 41, 43, 47, 49, 50, 51, 52, 53

Steve Schmidt

Module 1: Diversity--its meaning and relevance in nature

Age level: High school or junior high; for elementary grades see adaptation in Supplement #4

Subject: Biology **Theme:** Diversity

Sequence: Pre-field trip **Prerequisites:** None

Objectives: To introduce the concept of diversity; to show the importance of diversity in natural systems; to introduce characteristics of diversity one might find on the prairie (in preparation for a field trip); to arouse the curiosity and interest of students so that they will look forward to the field trip

Best season for investigation: Can be done in any season, including winter. Timing should be coordinated with the best season suggested in the field trip modules to be used following this module.

Time required: Approximately 3 hours (probably best done over a 2-day period)

Materials required (for high school and junior high):
- Slide-tape set #1: "Diversity" (available on loan from SKEEC)
- Student study sheet (Supplement #1) - one per student
- Student instruction sheet (Supplement #2 for high school or Supplement #3 for junior high) - one per student
- Microscopes as needed per requests
- Microscope slides
- Pond water
- Soil
- Stereoscopes as needed per requests
- Ink pad
- Slide-tape set #2: "Wild Flowers of the Prairie" (optional; available on loan from SKEEC)
- Film: "What Ecologists Do" (optional; available on rent from SKEEC)
- Film: "Grassland Ecology" (optional)
- Film: "Small Animals of the Plains" (optional)
- Film: "Prairie Killers" (optional)

Activities

Part I. Present the slide-tape set on "Diversity." This will attempt to define variety and give some input regarding the importance of diversity. Before presenting the slides, hand out the student study sheet (Supplement #1). This is intended to give some structure to the student's viewing. Point out the slides to which students are to respond (#4 on study sheet).

Part II. The following activities will help focus the idea that diversity and similarity in nature often go hand-in-hand. Have the students choose one or more activities from 1 to 5 and one or more from 6 to 8, and do them. (For junior high students, you may want to limit it to one of the first 5). They will probably benefit most by working in pairs.

The general instructions for any of the options are the same and are included on the student instruction sheet (Supplement #2 for high school or Supplement #3 for junior high).

1. Go to a farm where there is a large collection of animals of the same type. Cattle in a feedlot, chickens or hogs would be good examples. Choose one type and work on your assignment.

2. Go to a place where you can examine at least 10 trees fairly closely. Do the assignment given you.

3. Go to a lawn and choose one type of grass. By comparing individual blades or plants of that type, do the assignment (you can do this even in winter if the grass is brown).

4. Obtain an insect collection or butterfly collection (available from SKEEC). Do the assignment.

5. Find your own type of plants or animals to observe, and do the assignment. Single-celled animals, fish, water plants, dogs, cats and people are all options.

6. Obtain a stereoscope. Collect some sand or gravel which appears fairly uniform. Spread some out under the stereoscope and do the assignment.

7. Obtain a microscope and collect some very fine dust or soil. Put some on a slide and observe under the microscope. Do the assignment.

8. Take at least 5 people's fingerprints by pressing their thumbs to an ink pad and then on a piece of paper (more than 5 would be better). Then do the assignment.

Part III. To help increase the motivation and interest for the up-coming field trip to the prairie, some specific linking up of what ecologists do with "protecting the environment" should happen. Pointing out the relevance of ecological studies is one thing.

> Perhaps show the film, "What Ecologists Do" (available on rent from SKEEC)

Secondly, some "prairie appreciation" activity might be useful. A slide show of wild flowers, or some of the plants or animals they might likely see on the trip seems helpful. (SKEEC has a slide set on "Wild Flowers of the Prairie").

> Perhaps show a film, film loop, etc. on the prairie.
> Suggestions are:
> 1. "Grassland Ecology"
> 2. "Small Animals of the Plains"
> 3. "Prairie Killers"

Statement of Concepts

The concept of diversity as it applies to the natural world embodies a number of concepts within it. One such concept is simply variety. "Variety" is defined as the presence of many forms or units unlike each other.

Diversity, however, takes on even more meaning when it is understood alongside of similarity; for we often find similarity and diversity evident at the same time. For instance, different kinds of insects have very much in common. Even though we can distinguish them from each other based on differences (they may be different colors or shapes), we still know they are all insects because they have 6 legs, 3 body regions, and so on. So in nature it is helpful to think of diversity "within similarity," a kind of "controlled" diversity that has boundaries or limits or a framework within which to vary.

Scientists are discovering that in the natural world diversity can be a very valuable quality--valuable because it serves definite functions or purposes. One important general function diversity may serve is that of bringing stability to a system. It often does this by bringing protection from risks. An easily understood example of this is in diet or foods an animal eats. For example, if a kind of hawk ate only mice, and the mouse population declined, the hawks would be in trouble and would begin to starve. If, on the other hand, hawks had a diverse diet of mice, grasshoppers, moles and rabbits, a decline in the mouse population would not affect the hawks so drastically. Diversity in diet brings protection against starvation for the hawks. It brings a much more stable existence than the non-diverse diet.

Besides the function of bringing stability (insuring against risks), diversity promotes a more efficient use of the sun's energy. Any natural area (habitat) contains many different living things, and each of these living things seems to have its own role or function to fulfill in the system (its niche). Different species of plants, for instance, can live under different conditions within a habitat--some in shade, some in areas of little water, some with leaves high in the air, some with leaves low to the ground, some in the spring and some in the fall. No single type of plant could cover as much surface area--the individual plants would not grow well under all conditions. Collectively, many more leaves are exposed to the sun than would be the case with less diversity, therefore more energy is captured. Together they capture a much greater percentage of the sun's energy than can any of them singly. This concept can have far-reaching implications for food production and land use, and that is an important reason for bringing it up here.

The same idea of efficiency has been found with animal niches. If there are many different types of plants in an area, chances are no single species of animal would be able to utilize all the energy represented by all the different types of plants, even if the animal population were very large. Some plants would simply not be attractive to them. But if there are a variety of species of plant-eating animals present, more efficient use of the food would be made since collectively they would probably eat from all types of plants.

> "Perhaps the best known and most convincing illustration of this argument (the argument to maintain diversity) comes from Africa. Research shows that a mix of native animal species uses the land-

> scape more economically than imported livestock. Each of the different types of antelope and other game consume slightly different mixes of food plants or parts of plants, so that a whole assemblage of different species uses the landscape more efficiently than, say, beef cattle would by themselves." (Watt, 1972:82)

You can probably begin to draw your own conclusions about the importance of maintaining diversity in this world. If, by living as a part of this earth, we humans endanger the diversity of plants and animals and habitats and ecosystems, we will be decreasing the stability of the earth's support systems as a whole. If we are causing a destruction of the environment which is eliminating the variety of plant and animal life, in addition to decreasing the stability of the support systems, we are decreasing the efficiency of life to use the sun's energy. Decreasing the efficiency may have a number of far-reaching effects on the total system that we do not yet understand. One thing it seems likely to cause is a further decrease in the usable food supplies available to certain of the remaining living things, spiraling the extinction of species and the decrease in diversity.

Is there any evidence that diversity is being threatened?

Diversity and variety of living things is one of the "vital signs" that environmentalists watch. Just like nurses and doctors watch vital signs of patients, such as heart rate, blood pressure and respiration, environmentalists watch the world's vital signs. These include air and water quality, energy supplies, pollution levels, and diversity of wildlife. There seems to be bad news for the "patient" earth. For instance, of the 250 mammal species which have gone extinct since 0 B.C., 166 have succumbed in the last 50 years.[1] Some species become extinct "naturally," like the dinosaurs, but these figures indicate the extinction rate is increasing dramatically. Half of the butterfly species have disappeared in Holland in the last few decades. In the steppe region of Russia, conversion from wild areas to wheat fields has cut the number of insect species by 58%. (Watt, 1972:74-5) You are probably already aware of the endangered species of birds of prey--including our national symbol, the Bald Eagle. Right here in Kansas there are 23 species of fish (Platt, et al., 1974A), 11 species of amphibians and reptiles (Platt, et al., 1974B), 19 species of mammals (Platt, et al., 1974C), and 22 species of birds (Platt, et al., 1975) that are listed as threatened, endangered, or extirpated in the state.

So, the objectives of this module are to introduce the concept of diversity, to show its relevance to a healthy environment, and to introduce the characteristics of diversity one might find on a prairie.

We will want to have some activities which help students understand the concept of variety. We will also need some activities which will help students understand that there is often a relationship between diversity and similarity. Structured in these activities will be material and input on the relevance of diversity in our environment. And finally, we will need some materials which will prepare them to make observations in a following field trip activity.

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[1] From the film, "Say Goodbye," a David Wolpfer Production, The Quaker Oats Company.

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Module 1: Supplement #1
Student Study Sheet on Diversity

This can be done while viewing the slide series, or after, or both.

1. What does diversity mean? Define it or state an aspect of it.

2. What is one general way that diversity is valuable in nature?

3. What is another value of diversity?

4. Write your responses to the following slides. Include answers to each question listed below, but also feel free to write any other responses you might have.

   Slide of houses. How does it make you feel? What does it represent to you--diversity, similarity, or what? Explain.

   Dogs of all kinds. What does this represent to you? Make any response you wish.

   Wheat field. Would this be an efficient use of the sun's energy in this area? Explain.

   Milo or corn field. Would this be a fairly stable system or fairly unstable system? Explain.

   Would crop-harming insects likely have many natural predators or would the farmer likely have to spray poisons to control them? Explain.

5. Of the 250 mammal species which have gone extinct since the birth of Christ (0 B.C.), 166 have done so in the last 50 years. In the steppe region of Russia, the number of insect species has been cut by 58% by the conversion of wild areas to wheat fields. And right here in Kansas there are 75 species of fish, amphibians, reptiles, birds and mammals that are listed as endangered, threatened or extirpated.

   What is happening to diversity in this world? What effects might that have? What responses to this do you have?

Module 1: Supplement #2
Student Instruction Sheet - High School

This exercise is to help you focus on the ideas of diversity (or differences) and similarity (or sameness). Questions 1-3 should be done for each assignment the teacher gives. Questions 4-8 need be done only once.

Now that you have chosen from the list the teacher has given, get into a comfortable position and prepare to make some observations.

1. Look over the objects, plants, or animals--scan them and observe them briefly. Write down your first impressions. Let your mind think whatever thoughts you have about the things you observe and write them down.

2. Take a little more detailed look and list at least five ways that all the individuals are the same or similar, five things they have in common.

3. Even though they have a lot in common, if you study each individual long enough, you will probably soon distinguish some individual differences. You can probably see some unique things about each one. List at least six ways that individuals are different from each other. Write them down, being as specific as you can.

4. Suppose that, by some strange happening, a big change occurred in the things you are observing and after that change you could find absolutely no ways the individuals were similar. (Or imagine landing on a planet where you could find no two things with anything in common). Write your reaction. (If you don't have any reaction or don't know how to respond, answer this question: "Does it make biological sense to have no similarity between groups of animals or plants?").

5. Name one good reason why there are similarities in plants or animals.

6. Now imagine that, by some strange happening, a big change occurred in the things you are observing and all the individuals became exactly alike. You could find no ways any two were different. Write your reaction. (Or write your thoughts about how you would feel if everyone in the world looked exactly alike).

7. Name one good reason why there are differences in plants or animals.

8. Write a statement which says something about the relationship between differences and similarities as you have observed them in nature. (How do they relate in nature)?

Module 1: Supplement #3
Student Instruction Sheet - Junior High

This exercise is to help you understand the importance of diversity (or differences) and similarity (or sameness) in nature. Answer these questions for the activity you are assigned.

1. Look over the objects, plants, or animals. Are they similar? Or are they different? Write down your first impressions.

2. Look at them more closely and list at least five ways that all the individuals are similar, five things they have in common.

3. Study each individual closely. Can you find ways in which they differ from one another? List at least six ways that individuals differ from one another.

4. Can you imagine a world in which no two animals were similar? Can you think of one reason why there are similarities in animals? Write it down.

5. Can you imagine a world in which all animals were exactly alike? Can you think of a reason why there are differences in animals? Write it down.

Module 1: Supplement #4
Adaptation for Elementary Classes

Objectives: To observe differences and similarities and to appreciate their importance in nature

Materials required:
- Slide-tape set #2: "Wild Flowers of the Prairie" (available on loan from SKEEC)
- Microscope or stereoscope (optional)
- Pond water (optional)
- Soil (optional)

Activities

Part I. Discuss with the class the nature of differences and similarities within the class. Ask the class: How are we all similar to one another? After they have listed a number of ways, then ask: How do we differ from one another? Are any two of us exactly alike? Are differences important? Are similarities important?

Part II. Ask the class to do one or both of the following activities.

Ask the children either singly or in small groups to develop a TV commercial illustrating the value of variety. Some or all of the commercials may be presented to the class. Some suggested starters are: "Why we need different kinds of plants" or "Don't knock the person who is different from you."

Announce that the children will put on a skit called "What if everyone's name were John?" The plot is that all the children in Hometown, U.S.A. go to sleep one night and the next morning awake, each thinking his/her name is John. What happens when they get to their classroom at school? Discuss with the children what might happen and plan the skit. Practice the skit. For younger children you can play the part of the teacher but for older classes you may want to let the children do the whole thing.

Maybe you can present some of the commercials or the skit to another class and let the children explain the importance of differences and similarities.

Part III. Take the class to one or more of the situations suggested in Part II of the module or to other situations where differences and similarities can be observed. Discuss with the class the differences and similarities observed. Some of the following questions may be used to guide the discussion:

1. Are there any similarities in the objects, animals, or plants being observed? What are they?

2. Are there any differences in the objects, animals, or plants being observed? What are they?

3. What if every plant in the world were different (i.e. there would be one wheat plant, one corn plant, one oat plant, etc.)? How would the world be different? Would animals find it difficult to live? Would people find it difficult to live?

4. What if every plant in the world were the same (i.e. all wheat plants)? How would the world be different? Would there be any plants growing in swamps, in the Far North, etc.?

5. How would the world be different if all animals were the same, for instance, all cattle?

Part IV (optional). If a microscope or stereoscope is available, you can demonstrate to the class the variety in pond water or in soil.

Part V. Show the slide-tape set, "Wild Flowers of the Prairie." Before showing the slides discuss with the class the nature of the prairie and introduce the idea of the variety of plants in the prairie. Use the slide set to illustrate this variety and to arouse the interest and curiosity of the children to see a prairie.

Dwight Platt

Module 2: The components of diversity

Age level: High school

Subject: Biology **Theme:** Diversity

Sequence: Pre-field trip **Prerequisite:** Module 1

Objective: To study the components that contribute to diversity of an ecosystem and their significance to ecosystem structure and function

Time required: 45 minutes

Materials required:
Two boxes each containing 100 seeds--one box should have 20 seeds each of 5 different kinds of about the same size (red bean, white bean, sunflower, pea, etc.); the other box should have 2 seeds each of 9 different kinds and 82 seeds of a 10th kind

Activities

1. Diversity is not a simple concept. Ask the students in your class what they understand diversity to mean. After a short discussion, bring out the boxes of seeds and suggest that they investigate diversity in two different "communities" of seeds.

2. Divide the class into two groups (not more than 15 to 20 students in a group) and give each group one of the boxes of seeds. They are not to look at the seeds in the box at any time. They are to sample these "communities" of seeds. Ask them to shake the boxes. Then each student is to reach into the box and take out 3 seeds at random without feeling or selecting. Each group will then record how many students obtained 3 seeds all of the same kind, how many obtained 2 seeds of one kind and 1 different, and how many obtained 3 different seeds. Each group should also record the number of different kinds of seeds represented in all the samples picked by members of their group. The information from each group should be written on the chalkboard.

3. Compare the data obtained by the two groups. On the basis of their samples, ask them to judge which "community" of seeds is more diverse. What evidence supports this judgment?

4. Now each group should count the total number of different kinds of seeds in their "community" by examining the rest of the seeds in the box. These two numbers should be written on the chalkboard. On the basis of this evidence, which "community" seems more diverse? Is it the same community which was judged most diverse after sampling?

5. Discuss in what ways each "community" was diverse. Point out that each community was high in one component of diversity. The one box contained more different kinds of seeds, a diversity component that can be called "variety." However, all except one kind were very rare. The second box had one-half as many kinds of seeds but they were all equally common. It was high in a diversity component called "equitability."

6. What is the function of these two components of diversity to the structure and function of an ecosystem? Discuss this with the class, illustrating with examples from the prairie community (see Statement of Concepts). When man simplifies a community, which component does he affect? Give examples of situations in which he affects each of these components.

Statement of Concepts

Diversity of an ecosystem is a concept that includes "variety" or the number of different species in an ecosystem, and "equitability" or the evenness with which individuals are distributed among these species. There are many measures that have been proposed for diversity but most attempt to include both of these components. One measure that is often used is the Shannon-Weiner formula which you will find discussed in many ecology textbooks. It is derived from information theory and describes the degree of uncertainty in predicting the species of an individual organism picked at random from a community. If all individuals are of the same species, there is certainty in prediction and no diversity. The larger the number of species and the more equally the individuals are distributed among these species, the greater the uncertainty and the greater the diversity.

How does diversity affect a prairie ecosystem? Let us look at a simple example of one set of relationships in the prairie. A coyote eats animals that eat grass or other plants. If a coyote lives in a grassland in which there is only one species of herbivorous mammal, for example the cottontail rabbit, the availability of food for coyotes is directly related to the ups and downs of rabbit populations. If the grassland has two common prey species, the cottontail rabbit and the prairie vole, the coyote has an alternative source of food when one prey population declines. This increase in stability of the predation relationship is due to an increase in diversity of the system by adding to variety with high equitability. If the prairie vole is only a rare species, it adds as much variety to the ecosystem but not as much diversity because the equitability is so low.

Adding another common prey species to the ecosystem has a different significance to the coyote than adding a rare prey species. Only a moderately common species will be converting a significant amount of the plant resources into "coyote food" and so can serve as an alternative source of food. The greater the diversity in both variety and equitability, the greater the number of alternative relationships that may satisfy a need and the greater the number of alternative pathways for transfer of energy or food in the ecosystem.

Adding a rare prey species does not add an alternative food source for it is not converting enough of the plant resources into "coyote food." However under certain changed environment conditions, a rare species might increase in numbers and under these conditions becomes an alternative food source. If it is not present in the ecosystem even as a rare species, it is not even a potential alternative food source.

Of course the example given is an extremely simplified system because in reality the coyote will have many prey species in the prairie. But a large number of prey species makes for more stable relationships because each species can act as a buffer to lessen the effects of changes in another prey population. Of course diversity per se does not necessarily add to the stability of an ecosystem unless it adds to the diversity of adaptive relationships.

Natural ecosystems usually contain a very large number of species of organisms. However most of these species are rather rare and only a few are really common.

In managing ecosystems, man often tends to simplify them. The variety component of diversity may be affected when rare species are eliminated by changes induced by man. This often may reduce the potential stability of the system. Use of pesticides or heavy grazing can cause changes of this type. When the land is cultivated, both components of diversity are reduced and an unstable system is produced which can continue only with continued management by man. Odum (1975: 54-55) estimates that stable natural ecosystems generally have a diversity index of 0.6 to 0.8 on a scale of 0 to 1, while ecosystems managed by man may range down to 0.1 or 0.0.

References

1. Odum, Eugene P. 1971. Fundamentals of Ecology (3rd edition). Philadelphia: W. B. Saunders Co., pp. 143-154.

2. Odum, Eugene P. 1975. Ecology (2nd edition). New York: Holt, Rinehart and Winston, pp. 48-56.

3. Watt, Kenneth. 1972. Man's efficient rush toward deadly dullness. Natural History, vol. 81, no. 2, pp. 74-77, 80, 82.

Dwight Platt

Module 3: Let's study an insect

Age level: High school and junior high

Subject: Biology

Prerequisite: None. (This module should be used as preparation for the use of a key in identifying insects).

Sequence: Pre-field trip

Objective: To become familiar with the main external features that are used as key characteristics for identification of an insect

Time required: At least 1 hour

Materials required:

- One 10X hand lens per student or per 2 students
- One copy per student of the student instruction sheet for Module 3 (Supplement #1)
- One large grasshopper per student or per 2 students. (The teacher or students can collect these grasshoppers. The instructions best apply to the short-horned grasshoppers with antennae much shorter than the body. The grasshoppers can be collected ahead of time and preserved in 70% alcohol or 10% formalin. Preserved grasshoppers can also be purchased but the large lubber grasshoppers usually sold are not satisfactory for studying the wings).
- Slide set #3: "External Structure of a Grasshopper" (available on loan from SKEEC)

Activities

Hand out the grasshoppers and the instruction sheets to the students. You can then proceed in one of two ways:

1. Allow the students to work with the grasshoppers and the instruction sheet, proceeding on their own time. For younger students, you might have them read the article by Ross (1968) beforehand.

2. Borrow the set of slides from SKEEC that illustrates the external structure of a grasshopper. Show the slides and explain them using the accompanying script while the students are making the observations. Give the students sufficient time for reading the relevant part of the instruction sheet and making observations on the grasshopper before proceeding to the next slide.

Make sure that the students do the review called for at the end of the instruction sheet. You may want to quiz them on the parts of the grasshopper.

References

1. Ross, Edward S. 1968. Insects close up. Ranger Rick's Nature Magazine, vol. 2, no. 9, pp. 16-20 (November).

Module 3: Supplement #1
Student Instruction Sheet

Let's Look at an Insect

On our trip to the prairie, we will want to name some of the kinds of insects we observe. We will need to use a taxonomic key to identify these insects and this will require observation of the characteristic structures of insects. Therefore we need to recognize some of the parts of an insect and to understand how these parts fit together. So let's look at a grasshopper, an insect large enough that we can easily study these external parts.

What are some obvious differences between this grasshopper and a hopping vertebrate, such as a frog? One of the most obvious differences is the hard external covering over the body of the grasshopper. It is an outside skeleton or exoskeleton. Note that it is divided by grooves, lines, and/or joints into many exoskeletal plates.

Look at the rear part of the grasshopper behind the region to which the legs attach. Note that this part of the body is divided into a series of successive segments separated by grooves in the exoskeleton. The body of an insect is segmented, that is divided, along its length into a series of similar parts, although the segments are not as easily seen on the front part of the body. This segmentation involves some of the internal organ systems as well as the exoskeleton. In addition to this body segmentation, note that many of the elongate appendages, such as the legs, are divided by joints into a series of segments.

There are 3 regions in the body of an insect. The head is the first of these regions. The most obvious appendages on the head are the antennae (singular: antenna), or "feelers," which are attached to the upper front of the head. Note that each antenna is composed of more than 20 segments jointed together. Count the number of segments. You will need to count the number of segments in the antenna of some of the insects that you find in order to identify them. The antennae are attached to the head in front of the eyes in most insects, but, in some, the antennae are attached below the eyes. The antennae of grasshoppers are conspicuous and easily observed but they are very small and inconspicuous in some insects.

Just behind the antennae on the upper part of the side of the head are the large compound eyes. These are known as compound eyes because they are composed of many small hexagonal units observable under a microscope. Just in front of the upper front margin of each compound eye, above the base of each antenna, is a small simple eye or ocellus (plural: ocelli). A third ocellus can be found in the middle of the front of the head, just below the level of the attachment of the antennae. It is very small and difficult to find in some preserved grasshoppers. Ocelli are sometimes located on top of the head in other insects.

Around the mouth on the lower part of the head are some appendages known as mouthparts. The mouthparts of a grasshopper are adapted for chewing its food. Jointed to the lower part of the front of the head is a flat plate, the upper lip or labrum. Pull off the labrum and look behind it to find the 2 strong chewing mandibles with toothed edges. Behind the mandibles are a pair of thinner maxillae (singular: maxilla) and behind them a single lower lip or labium. Note that both the maxillae and labium have palps or jointed "feelers" on the outer sides. In some insects, the mandibles are not chewing organs and some of the mouthparts have been modified for lapping or formed into a beak or tube for sucking fluids.

Behind the head is the second region of the body, the thorax. The thorax consists of 3 segments, each of which bears one pair of legs. Look on the side of the thorax and identify the 3 segments (the legs attach near the rear of each segment). Can you find the grooves marking the boundaries of the segments on the lower surface of the thorax? The segments have grown irregularly and become partially fused to support the legs and wings and their muscles; therefore, they do not form regular rings around the body as they do in the rear region of the body. The last 2 segments of the thorax each bear a pair of wings. The plate of the exoskeleton on the upper surface of the first segment of the thorax is known as the pronotum. The pronotum in various insects may be narrow or may be variously expanded in front or behind over other parts of the body. It is an important structure to observe in identifying some insects. Is the pronotum of the grasshopper expanded over other segments of the thorax?

Study one of the second or middle legs. Find the 2 long segments of the leg which are jointed to one another. These are the femur (plural: femora) nearest to the body and the tibia (plural: tibiae) farthest from the body. Between the femur and the body are 2 short segments, the trochanter and the coxa (plural: coxae). The trochanter in grasshoppers is fused to the femur but it may be separate in other insects. Look on the lower surface of the femur at the end nearest the body. Can you find a narrow line or groove that marks the division between the femur and the small trochanter? The coxa is the narrow ring-shaped segment that is jointed to the trochanter and fits into the coxal cavity on the thorax. In a few insects, the coxa may be elongated. Attached to the end of the tibia is the fifth segment of the leg, the tarsus (plural: tarsi). The tarsus is divided into 3 subsegments in the short-horned grasshoppers. The third subsegment is longer and narrower than the other two while the second subsegment is very short, shorter than 1 or 3. Can you find the 3 subsegments of the tarsus? Look carefully on the upper side of the tarsus. Note that the claws and the fleshy pad between them are not counted as a separate subsegment but as structures attached to the tarsus. The tarsus in various insects may have from 1 to 5 subsegments and the number of subsegments in the tarsus is an important character used in identifying some insects. Look at the third or jumping leg of the grasshopper. Note how the femur is greatly enlarged to contain the muscles used in jumping.

Examine the wings. Note that there are 2 pair, each attached to a different segment of the thorax. Can you find the thickened supporting lines in the wing called veins? Some veins run longitudinally and they are connected by cross veins. An area of the wing enclosed by veins is a cell. The pattern of veins and cells in the wings is another character useful in identifying insects.

The abdomen is the third body region. It is divided into a series of ring-like segments, most of which have no appendages. Most insects have 11 or fewer segments in the abdomen. The grasshopper has 11 segments but some are modified or reduced. The first segment is divided into an upper and a lower part by the base of the third pair of legs. The lower part is fused to the last segment of the thorax. The upper part has an ear membrane on its side. Can you find the ear membrane? Can you count 8 ring-like segments on the upper surface of the abdomen including segment 1? Behind segment 8, there are two narrow rings evident on the side, segments 9 and 10. Segment 11 is represented by the terminal plate on the upper surface of the abdomen. On the lower surface of the abdomen, the lower plates of segments 1 through 7 and a long plate from segment 9 are evident.

Do you find a small pointed projection seeming to come out from the back edge of segment 10 on each side? These are cerci (singular: cercus). In some insects, the cerci are long and they may be jointed. If your grasshopper is a female, there will be 4 short heavy tooth-like structures on the end of the abdomen. These form the ovipositor which the female uses in digging a nest for her eggs. Some insects have long narrow or long sword-like ovipositors.

Now go back to see if you can find these various parts of the grasshopper:

1) head
2) compound eyes
3) ocelli
4) antennae
5) labrum
6) mandibles
7) palps
8) thorax
9) pronotum
10) coxa
11) trochanter
12) femur
13) tibia
14) tarsus
15) wings
16) veins
17) cells
18) abdomen
19) cercus
20) ovipositor

If you can recognize these parts of a grasshopper's body, you are ready to make the observations necessary to identify the insects you find.

Dwight Platt

Module 4: A shortcut to identification, the taxonomic or dichotomous key

Age level: High school and junior high (Procedure A)
Upper elementary (Procedure B)

Subject: Biology

Sequence: Pre-field trip **Prerequisites:** None

Objective: To acquaint students with the organization and use of a taxonomic key so that they can use keys in identifying organisms found in field studies

Time required: 1 hour for elementary school students; 2 hours, possibly 1 hour on each of two days, for high school and junior high students

Materials required:

Boxes (one box for each 4 students) containing 10 different small objects --for older students these objects can be fresh cuttings of different plants, a series of different shells, or other biological materials; for younger students these objects should be common items such as nails, screws, toothpicks, small blocks of wood, rubber washers, rubber bands, etc.
A collection of leafless twigs (high school and junior high) or twigs with leaves (elementary)--willow, elm, cottonwood, ash, boxelder, mulberry, black walnut, osage orange, or black locust (at least one twig per student; available on loan from SKEEC)
A key to twigs (Supplement #1 or #2); duplicate one copy for each student
Flow chart sheets (Supplement #3) - 5 sheets per 4 students
String
Magic tape

Activities

Procedure A (for high school and junior high students):

1. Divide the class into groups of 4 students each. Give each group a leafless twig. In order to identify this twig or find the correct name of the tree from which it came, it might be compared with descriptions or illustrations of the twigs from all the trees that grow in this area. Ask the students if they would like to do this. This would be a very time-consuming task. Biologists use a taxonomic key as a shortcut to identification. It is a way of systematically reducing the possibilities until the correct name is found. Point out to the students that they will need to use a key in identifying animals found on the field trip that is being planned, so today they will learn about a taxonomic key. If you plan to do the whole exercise on one day, you can have the students lay the twigs aside to be used later. Otherwise pick up the twigs and hand them out again on the next day.

2. Give five flow chart sheets, some string and tape, and a box containing 10 different small objects to each group of students. Ask each group to take one flow chart sheet and arrange all 10 objects from the box in two groups or categories placed in boxes A and B on the left of the flow chart sheet. Each category must have a defining characteristic. These characteristics must be mutually exclusive so that no object can have both characteristics. These will usually be alternative expressions of a single character, such as leaves with pointed tip or leaves with blunt tip. The two characteristics must be inclusive of all the objects so that each object has one of the characteristics. Encourage students to use all of their senses in examining the objects to find defining characteristics for the categories. When they have divided the objects into two categories, ask them to write the defining characteristic for category A in box A of the flow sheet and the defining characteristics for category B in box B.

3. Have each group read the characteristics they have written for the two categories. If they have made any of the following mistakes, point out how the statements can be improved.

   a. Categories not mutually exclusive.

      (1) Overlapping characteristics.

         Example: 1A. Length, 1 inch or more.
         1B. Length, 1 inch or less.
         (Objects that are 1 inch long fit in both categories).

      (2) Not alternative characters.

         Example: 1A. Long slender object.
         1B. Object with a pointed tip.
         (An object could have both characters).

   b. Categories not inclusive of all items.

      Example: 1A. Red in color.
      1B. Blue in color.
      (These two categories are inclusive only if all objects are either red or blue. If some objects are yellow, they do not fit into either category. Inclusive categories could be characterized in this case as follows:
      1A. Red in color.
      1B. Not red in color).

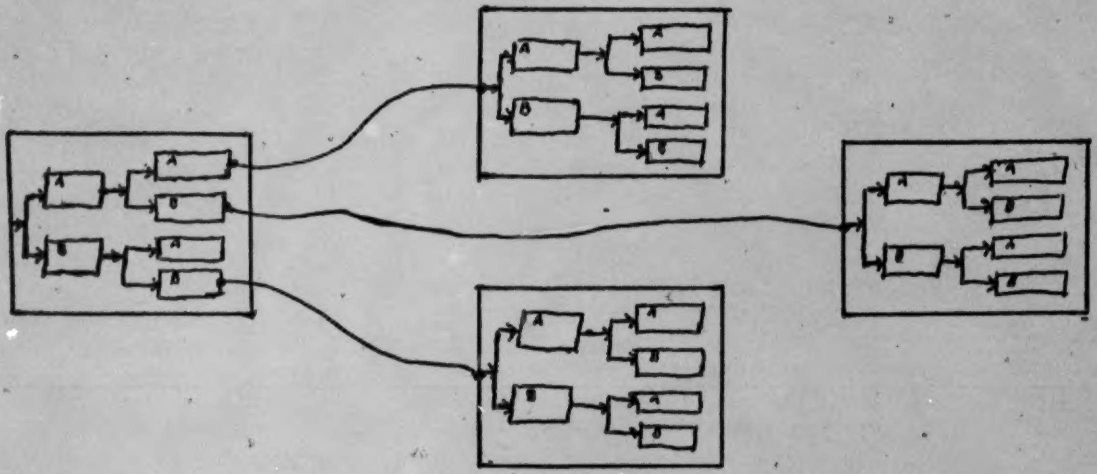
   c. Categories are defined by characters that cannot be observed.

      Example: 1A. Plants with medicinal properties.
      1B. Plants without medicinal properties.
      (The medicinal properties of a plant cannot usually be observed and can only be determined by experimentation or by reading once the name of the plant is known).

4. Now ask each group to take the objects in category A and divide them into two categories (using the procedure described in #2 above), placing them in boxes A and B at the upper right of the flow chart sheet. Also ask them to take the objects in the original category B and divide them into two categories, placing them in boxes A and B at the lower right

of the flow chart sheet. The defining characteristic for each category should be written in the box. If any box contains only one object, this category should be named since it cannot be further subdivided. The name given should be the common name of the object or the students can invent a name for the object. The name should be written below the statement of the defining characteristic in the box.

5. All categories that contain more than one object should continue to be subdivided and they can be subdivided into boxes on new flow chart sheets. Pieces of string should be taped in place to show which categories were subdivided on which sheets. See diagram.



The process of subdivision should be continued until all of the objects have been divided into categories that have only one object per category. Each group has now constructed a flow chart key to the 10 objects.

6. Ask each group of students to remove all of the objects from the boxes of the flow chart and put them back in the box. Now they should exchange places with another group so that they have the box of objects and the flow chart key of the other group. They should now take one object from the box and decide whether it fits into the original category A or B on the first flow chart sheet. They can then proceed step-wise following the arrows and deciding at each step into which of the two categories it fits. This process should be continued until the object fits in a named category. This name is the identification of the object. Have each group identify 3 or 4 of the objects using the key.

If a group has trouble finding the correct names for the objects, check to see if the key is written correctly. If it is, help them to use it. If it is not written correctly, help the group which wrote it to correct it.

7. Discuss the nature of a key with the students. The key is a logical shortcut to use in identifying objects. Each step is written to limit the possibilities to a smaller group of objects and to eliminate a number of possibilities--all those objects that fit in the other category.

8. The steps in the flow chart key need to be numbered. For younger students, you may want to stop for the day at this point and then number the steps for them before you take up the activity again on another day. Older students can be asked to number the steps of the key they have written. The first A and B categories on the original flow chart sheet should be numbered 1A and 1B. Then proceed with numbering following these rules:

    a. The next number should be given to the step which subdivides category A each time (category 1A is subdivided in step 2 into 2A and 2B; category 2A is subdivided at step 3 into categories 3A and 3B; etc.)

    b. When a category A is reached that is a named category and cannot be further subdivided, proceed to category B of that number and the next step will subdivide it, if it can be subdivided. However, when it is subdivided, proceed as in 1 above to subdivide the A categories until another named category is reached. (For instance, if 3A is a named category, proceed to 3B and the fourth step will subdivide 3B into 4A and 4B. If 4A can be subdivided, the fifth step will subdivide 4A into 5A and 5B).

    c. When a B category is also a named category and cannot be subdivided, proceed to the B category with the next lower number and the next step will subdivide it. (For instance, if 3A is a named category, proceed to 3B. If 3B is also a named category, proceed to 2B and the fourth step will divide 2B into 4A and 4B).

    Continue numbering until all of the steps have been numbered.

9. Point out to the class that taxonomic keys involve this procedure of using a series of steps with a pair of alternative mutually exclusive choices at each step. However, most taxonomic keys are not written in the flow chart format because it is somewhat unwieldy. A common format for taxonomic keys is the bracket key which can easily be constructed from a flow chart key. Each group should construct a bracket key from the flow chart key in the following way. The pairs of categories should be listed in order with alternate ones indented:

    1A.
    1B.

        2A.
        2B.

    3A.
    3B.

        etc.

    After the number of a category, its characteristic should be written. Then to the far right should be written the number of the two categories into which it was subdivided, or its name if it is a named category. An example of a bracket key for 6 objects follows:

1A. Made of metal, grayish with metallic luster and ring 2
1B. Not made of metal, not grayish and without metallic luster or ring 4

2A. Cylindrical shaft with a spiral groove along more than 2/3 of its length and with a grooved cap on one end . . . 3
2B. Cylindrical shaft without spiral groove and with flat cap on one end . . . . Nail

3A. End opposite the cap pointed . . . . Wood screw
3B. End opposite the cap not pointed . . . . Bolt

4A. Circular object with hole in center; red . . Rubber washer
4B. Not circular; not red 5

5A. Elongate, length more than 20 times any other dimension . . . . Toothpick
5B. All dimensions equal . . . . Square block of wood

After the students have written bracket keys, they should use them to identify one of the objects. If they have trouble, check to see if the key is written properly. If it is, help them to use it. If it is not written correctly, help them to correct it.

10. Another format for taxonomic keys is the indented key. Have each group take the bracket key they have written and rewrite it as an indented key. An indented key is written in outline form with the next step immediately following each alternative chosen. The taxonomic keys available with these curriculum materials are indented keys. The sample bracket key in #9 can be rewritten as the following indented key:

1A. Made of metal, grayish with metallic luster and ring.

- 2A. Cylindrical shaft with a spiral groove along more than 2/3 of its length and with a grooved cap on one end.
  - 3A. End opposite the cap pointed . . . . Wood screw
  - 3B. End opposite the cap not pointed . . . . Bolt
- 2B. Cylindrical shaft without spiral groove and with flat cap on one end . . . . Nail

1B. Not made of metal, not grayish and without metallic luster or ring.

- 4A. Circular object with hole in center; red . . Rubber washer
- 4B. Not circular; not red.
  - 5A. Elongate, length more than 20 times any other dimension . . . . Toothpick
  - 5B. All dimensions equal . . . . Square block of wood

Have each group attempt to identify one or two objects using the indented key.

11 (optional). Have each two groups of 4 students combine into a group of 8 students. Ask each group to write an indented key that can be used to identify the students in their group. Check over these keys to see that they are written correctly.

12. Give each student a twig and a copy of the twig key. Ask them to identify the twigs using the key. Check their identifications to be sure they have used the key correctly. You can ask them to identify another twig if they still have trouble using the key. Emphasize that in using a key, students need to:

    a. Determine the pair of characters to be compared to the specimen at each step.

    b. Be sure they understand the meaning of terms used in the key and therefore understand the difference between alternative characters.

    If they are not sure which decision to make at any step, they can try both decisions and see in which case subsequent decisions best fit the specimen.

Procedure B (for upper elementary school students):

1. Give each student a twig from a tree. In order to identify this twig or find the correct name of the tree from which it came, it might be compared with descriptions or illustrations of the twigs from all the trees that grow in this area. Ask the students if they would like to do this. This would be a very time-consuming task. Biologists use a taxonomic key as a shortcut to identification. Point out to the students that they will need to learn to use a key so that they can identify some of the animals they find on the field trip to the prairie.

2. Divide the class into groups of 4 to 6 students. Give each group a box containing the same 10 different objects. Make a flow chart key according to the procedures described under steps #2 to #5 of Procedure A, except that it should be done as a whole class. As the class decides on categories and their characteristics, make the flow chart key on the chalkboard.

3. When the flow chart key has been completed on the chalkboard, have each group take the same object out of their box and then go through the process of identifying it by using the key. Point out to the students that the key consists of a series of steps and at each step a decision must be made between two categories. These steps gradually reduce the number of objects in each category until finally a category is reached that contains only one object and provides a name for it.

4. After the students understand the key they have constructed, give each student a copy of the key to twigs (Supplement #2) and see if they can identify the twigs they were given at the start of this activity. Help those who have difficulty using the key to get a correct identification.

References

1. Anonymous. 1968. Quiz for leaf collectors. Ranger Rick's Nature Magazine, vol. 2, no. 3, pp. 35-37 (March).

Module 4: Supplement #1
A Key to the Leafless Twigs of Nine Common Trees
(High School and Junior High)

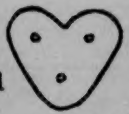
Examine the twig and find the buds along it. The place on the twig where a bud is joined is a node. Below each bud at the node is a leaf scar, a scar left when a leaf dropped. Within each leaf scar are one or more bundle scars, where the veins in the leaf stem attached.

1A. 2 leaf scars and buds at each node, 1 on each side of the twig.

2A. Leaf scars from two sides meet to form a line clear around twig . . . . **Boxelder**

2B. Leaf scars do not form a line clear around twig; buds low and rounded . . . . **Ash**

1B. Only 1 leaf scar and bud at each node of twig, or, if more than 1 bud, then both are together on the same side of the twig.



3A. Pith of twig chambered (if part of twig is split lengthwise, the central pith is hollow with a series of air spaces and closely spaced septa or walls across it); leaf scar is heart shaped with 3 bundle scars . . . . **Black Walnut**

3B. Pith not chambered; leaf scar not as above.

4A. Small bud situated near the center of the leaf scar; usually 2 small thorns can be felt on either side of the leaf scar . . . . . **Black Locust**

4B. Bud located above the leaf scar, not near the center of it; if thorns are present, there is only 1 at each node.

5A. Only 1 bud scale visible covering the outside of the bud; twigs very thin . . . **Black Willow**

5B. 2 or more scales visible covering the outside of the bud; twigs not very thin.

6A. More than 3 bundle scars in the leaf scar; stipule scar usually evident as a small ridge extending from both sides of leaf scar . . . . . . **Mulberry**

6B. 3 bundle scars in the leaf scar; stipule scar not forming a definite ridge on both sides of the leaf scar.

7A. Bud small and rounded at the tip; 1 thorn sometimes present at nodes . . . . Osage Orange

7B. Buds with pointed tips; no thorns.

  8A. Pith obvious, appears star-shaped or 5-sided in cross-section; twig often with longitudinal ridges; buds appear shiny and covered with resinous material; buds and leaf scars do not regularly alternate on opposite sides of the twig . . . . . Cottonwood

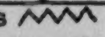
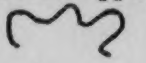
  8B. Pith small, circular in cross-section; no longitudinal ridges on twig; buds not appearing resinous, but slightly wooly; buds and leaf scars regularly alternate on opposite sides of the twig so that every other bud is in a line on one side . . . . American Elm

Module 4: Supplement #2

A Key to the Summer Twigs of Nine Common Trees

(Elementary Grades)

For background on the structure of a leaf, have the students read the article in Ranger Rick's Nature Magazine listed in the module references.

Examine the twig. The point at which a leaf joins to the twig is a node. Some leaves consist of more than one leaflet on a flexible stem. These are compound leaves. Others are simple leaves, not divided up into leaflets. Teeth on the margins of the leaves appear like the teeth of a saw, as  . Lobes are portions of the leaf divided off by indentations.  Break a leaf off the stem. Note the small bud that lies just above where the leaf attached.

- 1A. Leaves are opposite--a leaf is found on each side of the stem at each node. →
  - 2A. Compound leaves--each leaf is composed of 3 to 5 leaflets; the margins of most of the leaflets have coarse teeth or lobes; the bud is hidden underneath the base of the stem of the leaf--BOXELDER.
  - 2B. Compound leaves--each leaf is composed of 5 to 11 leaflets; the margins of the leaflets have fine teeth; bud can be found just above the base of the stem of the leaf--ASH.
- 1B. Leaves are alternate--there is only one leaf attached to the stem at each node, but leaf may be composed of leaflets. →
  - 3A. Simple leaves--leaf is single, not composed of 3 or more separate leaflets. →
    - 4A. Margins of leaves have teeth; there are no thorns on twigs. → to next page
    - 4B. Margins of leaves are smooth, without teeth; some twigs have thorns--OSAGE ORANGE.
  - 3B. Compound leaves--each leaf is composed of a series of leaflets. →
    - 8A. Margins of leaflets are smooth, without teeth; 2 small thorns can be felt, one on either side of the base of leaf, on many nodes of the stem--BLACK LOCUST.
    - 8B. Margins of leaflets have fine teeth; no thorns on the stem--BLACK WALNUT.

5A. Leaves are narrow and long, at least 5 times as long as wide; only 1 main vein is easily seen in leaves; branch veins are difficult to see; twigs are thin--BLACK WILLOW.

5B. Leaves are 3 times as long as wide or less; main vein and branch veins are easily seen in leaves; twigs not very thin. →

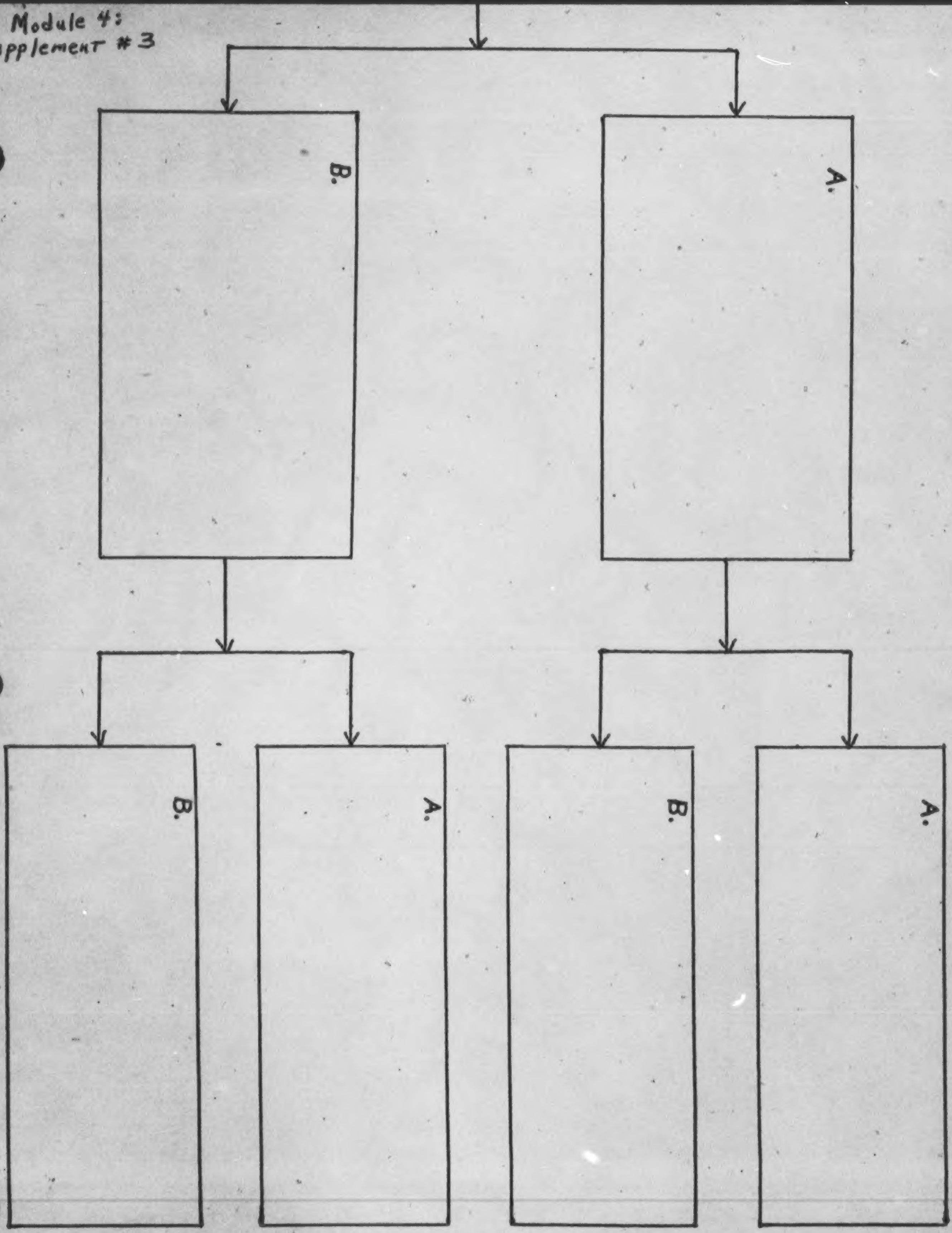
6A. 12 or more easily seen branch veins come off the main vein on each side; margins of leaves with coarse teeth, with smaller teeth on many of the coarse teeth; stem of leaf is short, not more than 3 times the length of the bud--AMERICAN ELM.

6B. 10 or fewer easily seen branch veins come off the main vein on each side; margins of leaves have teeth or sometimes have lobes, but there are no smaller teeth on the large teeth; stem of leaf is long, at least 7 times the length of the bud. →

7A. Stem of leaf is very much flattened near the base of the leaf; leaf is as wide or wider than it is long; veins are seen and felt as easily on the upper surface of the leaf as on the lower--COTTONWOOD.

7B. Stem of leaf is not flattened near the base of the leaf; leaf is longer than it is wide; veins can be very obviously seen and felt on the lower side of leaves but less obvious on the upper side--MULBERRY.

Module 4:
Supplement #3



Dwight Platt

Module 5: The web of interdependence

Age level: Grades 3 or 4 (can be adapted for other elementary grades)

Subject: Biology **Theme:** Interdependence

Sequence: Pre-field trip **Prerequisites:** None

Objectives: To introduce the ideas of interrelationship and interdependence; to understand the various types of interrelationships between organisms and the way animals and plants live together in communities and ecosystems; to gain an appreciation for the complex web of interrelations and the interdependence of animals and plants in a prairie community

Time required: 1½ to 2 hours (it may be done in three different short periods, or Part I may be done on one day and Parts II and III on the next day)

Materials required:

Pieces of heavy string of various lengths (at least three times as many pieces as the number of children in the class, and in lengths from 5 to 15 feet)

Slide-tape set #4: "Interdependence on the Prairie" (available on loan from SKEEC)

Activities

Part I. Understanding interrelationship and interdependence

1. The first part of this activity can best be done out on the playground although it can be adapted for use indoors. Pick a place where circles can be drawn in the dust or sand or on a pavement. Instruct the class to spread themselves out in an irregular group with about five feet between nearest neighbors. Now stretch the pieces of string between students in a web-like fashion so that each child has from 2 to 4 strings in each hand. The strings should all be held rather taut with the children's hands at their sides. Instruct the students to be careful not to break the strings and not to raise their hands from their sides. When they have completed this arrangement, draw a circle around the feet of each child.

   Now pick a student on the periphery of the group and ask him/her to move away from the group about five feet. Tell all the other students to move if they need to but to stay within the circle around their feet if they do not have to move. They do not need to keep all strings taut but they should not raise their hands nor break any strings. Count how many students had to leave their circles and how many could stay within their circles.

   Now let the students go back to their original circles. Pick another student on the periphery and have him/her move five feet. How many students had to move this time? Were they the same students? Did all students have to move the same distance outside their circles?

Have them lay down the strings where they are standing and all come into a group to discuss what they have demonstrated. Discuss the nature of the relationships within the group. It was a forced leader-follower relationship. Was it an interrelationship? Does a change that affects a web of interrelationships like this affect each student somewhat differently?

2. After a short period of discussion in which the concept of relationship and interrelationship are clarified, ask the students to go back and get in their original circles and pick up their pieces of string again. Then draw a circle around the whole group of students. Now instruct all students to move outside of the larger circle. After a short time if this has been accomplished or there is a stalemate, stop the activity. Come together again for a short discussion of interdependence. They should see that in trying to move outside the circle, they were operating as an interdependent group. In order to complete the task, each student was dependent upon the other members of the group.

3 (optional). If there is still time and interest, have them line up with each person placing his/her hands on the shoulders of the person in front. The teacher may want to take the lead position. Now start the line moving and tell everyone simply to follow the person in front. After a time point out that this is another dependent situation, a leader-follower situation, but one with less interdependence. The dependence all goes in one direction.

Part II. Understanding interdependence in a community

1. This part of the activity will take place in the classroom. Ask the students what a community is. Lead them to a discussion of a community as an organized group of people living together. Now ask them to name persons with different functions in a community. As they name categories like businessmen, doctors, farmers, policemen, etc., write them on the chalkboard in a pattern that resembles the pattern of their group on the playground. When you have a number of categories written down, ask them what type of relationships these various persons have with one another. You can connect the names with lines and then indicate the type of relationship. Do you end up with a web of relationships like the web of relationships on the playground? Is it an interdependent web? Do the people in the community need this web of relationships in order to live? Could any one live independently of the web?

2 (optional). The same sort of analysis could be done for the school as a community. The list might include students, teachers, custodians, principal, secretaries, school nurse, etc. The discussion could center around the type of interdependent relationships that are important in the functioning of the school.

3. Point out that animals and plants live in interdependent communities in which each kind of organism has its specific role. The community is also dependent on the soil, air, climate, etc. to satisfy many needs. This system of a community and its physical environment is an ecosystem.

4. Read one or more of the following articles to the class and discuss the interrelationships characteristic of the animals or plants described: Mech (1971), Fischer (1969), Gray (1972), Leister (1969), Grant (1969), Shiner (1969).

Part III. Understanding interdependence in a prairie community

Use the slide-tape set #4, "Interdependence on the Prairie," to illustrate various types of relationships and the way they are woven into a web of interdependence on the prairie.

Statement of Concepts

Interdependence is often stated as the "everything is connected to everything else" principle. Interdependence in a natural community (a group of animals and plants living together on an area) means that animals and plants in that community are dependent on one another in various ways. It implies that there are relations between organisms and that these are mutual relationships or interrelationships in which each is affected. And the fact that these are dependent relationships suggests that no one organism can live to itself but needs these relationships with others for survival. The members of a community also depend upon the physical environment to supply some of the needs for survival and this system of a community plus its physical environment is what the ecologist calls an ecosystem.

In its effect upon the individual organisms involved, an interrelationship may be harmful or beneficial. A red-tailed hawk swoops down to catch and eat a harvest mouse. This relationship obviously benefits the hawk because it gets a meal and it is harmful to the mouse which dies. But even though the relationship is harmful to the individual mouse, it may be beneficial to harvest mice in general because it is part of the mortality which regulates the mouse population so that it doesn't grow to exceed its resources. Therefore the harvest mouse population may be dependent for its continued healthful survival upon predation by the hawk just as the hawk is dependent upon the harvest mice as a source of food. This is a case of direct interdependence. It is important to realize that this type of dependence has no emotional connotations like a child-parent dependence. There is no love or hate between hawk and mouse and it shouldn't be presented to the child in such a way as to indicate such emotions. It is simply that both hawk and mouse populations function more effectively when related in this way than they would independently and anything that affects one population will probably also affect the other.

Not all interdependence is as direct as the example given. A crab spider sitting in a flower waiting to prey upon an insect that comes to visit the flower is obviously dependent upon the plant to provide a situation in which it has a better opportunity to catch its prey. The importance of this relationship in the adaptation of the spider may be indicated by the coloration of the spider which in many cases matches the flower. The spider is also dependent upon the insect that visits the flower and is caught for food and the interrelationship between predator and prey is obvious. But any dependence of the plant upon the spider is less obvious and much more indirect.

However, if the spider has a direct relationship to the insect that comes to pollinate the flower and becomes a meal for the spider and if the plant and its insect pollinator have a direct relationship, then certainly the spider and the plant have an indirect relationship.

Such interrelationships in nature do not all involve food, although food relationships are very important. The tree that provides shade and therefore lowered temperature for an animal or the shrub which serves to support a bird's nest are obvious ecological relationships. In these cases, the dependence may be in only one direction since the tree is not dependent on the animal sitting in its shade nor the shrub on the nesting bird.

We can study interdependence from two points of view. We can look at the individual organism or species and focus on how it is related to other organisms in the community. Or we can focus on the organisms that make up the community and try to understand at least a part of the web of relationships between them. In the first case we are defining the relationships that allow the survival of a species as a part of a community. In the second case we are picturing the relationships that structure a community and allow it to function as an integrated whole.

References

For the teacher:

1. Allen, Durward L. 1967. The Life of Prairies and Plains. New York: McGraw-Hill, pp. 126-167.

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1. Anonymous. 1974. Life on the prairie. Ranger Rick's Nature Magazine, vol. 8, no. 2, pp. 17-22 (February).

2. Fischer, Richard B. 1969. Predators, we need them. Ranger Rick's Nature Magazine, vol. 3, no. 2, pp. 12-15 (February).

3. Grant, Ruth. 1969. Ladybug. Ranger Rick's Nature Magazine, vol. 3, no. 9, pp. 16-18 (November).

4. Gray, Robert. 1972. Links of life--food chains. Ranger Rick's Nature Magazine, vol. 6, no. 1, pp. 17-21 (January).

5. Leister, Mary. 1969. The aphid lion. Ranger Rick's Nature Magazine, vol. 3, no. 5, pp. 18-19 (May/June).

6. Mech, Dave. 1971. The lesson of Isle Royal. Ranger Rick's Nature Magazine, vol. 5, no. 1, pp. 24-27 (January).

7. Shiner, Don. 1969. Lichens. Ranger Rick's Nature Magazine, vol. 3, no. 9, pp. 28-32 (November).

8. Sokolski, Ken. 1974. Once there was a field. Ranger Rick's Nature Magazine, vol. 8, no. 5, pp. 40-41 (May/June).

Dwight Platt

Module 6: Interdependence in an ecosystem

Age level: High school (can be adapted for junior high by omitting Part I, sections 1 to 5, and presenting the other parts of the module at the level of your class)

Subject: Biology **Theme:** Interdependence

Sequence: Pre-field trip **Prerequisites:** None

Objectives: To introduce the concepts of an ecosystem, a community, a food chain, a food web, and an ecological niche; to gain an understanding of interdependence as a primary characteristic of an ecosystem; to gain an appreciation for the complex web of interrelations and the interdependence of animals and plants in a prairie ecosystem

Time required: 1 hour for Part I; 1½ hours for Parts II and III on another day

Materials required:
Slide-tape set #4: "Interdependence on the Prairie" (available on loan from SKEEC)

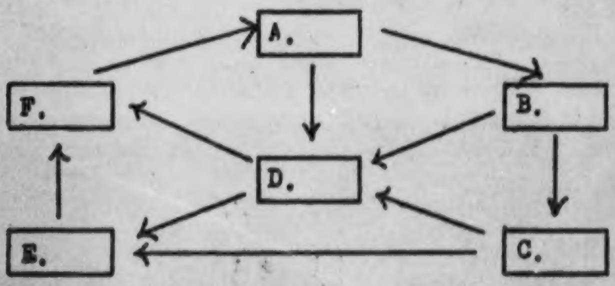
Activities

This module introduces a number of concepts that are needed for the investigations in some of the field trip modules. Some of these concepts may already be familiar to your class. If so, you can skip over those parts of this module. Optional parts of this module are not necessary for the field trip investigations but suggest further studies that would be valuable in understanding interdependence in an ecosystem.

Part I.

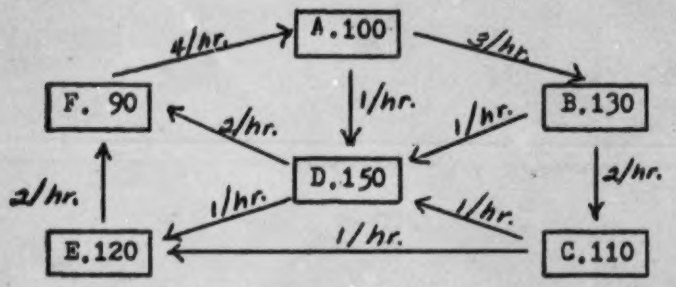
1. Write the word system on the chalkboard. Ask the class what they understand by this word. After you get some suggestions from the class, discuss the definition from Webster's dictionary given in the statement of concepts at the end of this module. You can use as an example one of the systems of the human body, the digestive system or the circulatory system. Discuss how a system differs from a group of objects that are not interacting (such as a pile of pebbles). Point out that various kinds of animals and plants live together in interrelated systems as they eat one another, provide shelter, etc.

2. Draw the following diagram on the chalkboard:



Point out to the class that this is a diagram or model of a system. What do the boxes represent? They represent the components of a system (the various organs in a digestive system or the various species of organisms that live together in a system). The structure of a system is described in terms of the kinds and sizes of these components. But the system is dynamic, and this dynamic function is indicated by the arrows that represent interrelations between the various components. These arrows can represent the flow of some material (for instance, the flow of a liquid between a series of closed tanks through pipes in a liquid piping system or the passage of a chemical, like phosphate, from one animal to another by feeding). They can also represent the effect of one component upon another without any transfer of matter.

3. Point out to the class that the various components and the arrows in a system can sometimes be quantified, particularly when the arrows represent the flow of a material that takes place at a measurable rate. Add the following numbers to your diagram:



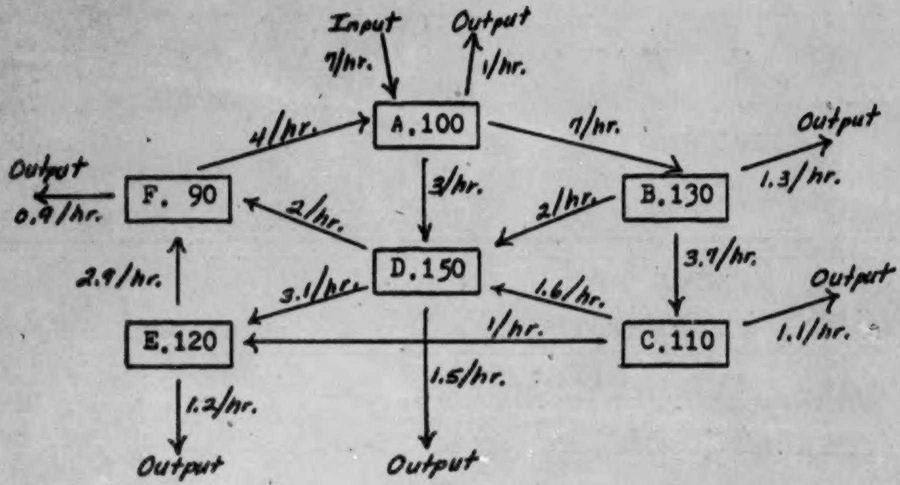
These numbers represent some unit of measure of volume or weight.

Ask the class whether the structure of the system that is diagrammed is changing. Point out that there is no change because the inputs into each box equal the outputs. This system is in equilibrium.

4. Now change the flow between boxes A and B from 3/hr. to 4/hr. Ask the class what will happen to the system. Be sure it is noted that after 100 hours, box A will be zero and box B will have increased to 230. The structure of the system will have greatly changed, and it may even cease to function if there is no way to maintain the flow without box A.

Ask the class to make adjustments in other flow rates to bring the system back into equilibrium. Give them a few minutes to work on the problem and then ask those who have suggestions to put them on the chalkboard. Check to see that the suggested systems are really in equilibrium. There are a number of different ways the system could be brought into equilibrium, but each will involve adjustments in the flow rate between a number of different boxes. These are homeostatic adjustments. Homeostatic adjustments to changes in a system are necessary if it is to remain stable.

5. The system that has been modeled is a closed system. All flow takes place within the system. An open system also makes exchanges external to the system. You can illustrate an open system by the following diagram:



6. Point out to the class that all living organisms live in systems known as ecosystems. The animals and plants that live together and are interrelated in an ecosystem are known as a community. See that the class understands the nature of an ecosystem and a community.

7. Divide the class into groups of 4 to 6 students and make assignments to each group to explore the interrelationships of certain animals. These assignments can be made in either of two ways:

   a. Assign a particular animal to each group and ask members of that group to use reference books to learn all they can about the animal.

   b. Assign particular readings to each group and ask them to look for interrelationships between animals and other animals and/or plants and/or physical factors as they read the assignment. Some suggested readings are: Allen (1974), McMahan (1975), Mech (1974), Schaller (1972), Becker (1965), Brander and Books (1973), Ehrlich and Raven (1967), and Amos (1959).

Part II.

1. Briefly review with the class what was discussed in Part I. Point out that the various species of animals and plants in an ecosystem are interrelated and can be diagrammed by a series of boxes and arrows. You can make a diagram similar to those in Part I, labeling the boxes "species A," "species B," etc. However, such a diagram does not include the whole ecosystem because each species also has relationships with physical components of the ecosystem such as soil, air, water, climatic conditions, etc.

2. Point out to the class that no organism can live without relationships to other components of an ecosystem that supply its needs for food, air, water, shelter, etc. Each species is interdependent with many other species in its ecosystem; that is, it is dependent on them for

its survival. Each species has its place in the ecosystem, known as its ecological niche, which is defined by its relations with other components, such as what it uses for food, what uses it for food, what provides shelter, the temperature and water relationships it needs throughout the day and throughout the year, etc.

3. Man as a living organism is also interdependent within ecosystems. Ask the class to make a list of important relationships between man and other organisms that are necessary for man's survival and that illustrate his interdependence within ecosystems. List these on the chalkboard.

4. One of the most important types of relationships within an ecosystem are feeding relationships that supply organisms with energy and with certain chemicals that they need.

   Write the following equations on the chalkboard:

   Photosynthesis

   Water + carbon dioxide + light energy from sun → food (as carbohydrate--sugars, etc.) + oxygen

   Respiration

   Food (as carbohydrate--sugars, etc.) + oxygen → energy for living activity + carbon dioxide + water

   Discuss the dependencies inherent in the photosynthesis and respiration reactions. The materials used in one reaction are the products produced by the other. Discuss the nature of food chains that always begin with green plants. Also point out that food chains are interconnected as food webs in an ecosystem.

5 (optional). You can develop the idea of feeding relationships further, introducing the ideas of trophic levels and ecological pyramids. Discussions of these topics can be found in any introductory discussion of ecology (see Kormondy, 1969, or other books).

6. Ask the class to make a list of types of ecological relationships other than feeding relationships. Things that may be mentioned are shelter to provide suitable temperatures or humidities, support or materials for a nest, concealment to hide from predators, provision of gases needed such as oxygen, protection for a dormant or developmental stage, etc.

7 (optional). You can further explore the pattern of close relationships by considering examples such as parasitism, mutualism, commensalism, predation, etc. (see any general biology book).

Part III.

1. Have the class divide into the small groups that were given assignments in Part I, #7. Give the groups time to discuss the materials they have read and to compile a list or a diagram of interrelationships between an animal and other components of its ecosystem that were mentioned in the material read.

2. Have a representative from each group report on the results of their study to the entire class.

Part IV.

Use the slide-tape set #4, "Interdependence on the Prairie," to illustrate some of the types of interdependent relations to be found in the prairie.

Statement of Concepts

The environment of a living organism is more than its environs; it is a system. A system is defined by Webster's dictionary as "a regularly interacting or interdependent group of items forming a unified whole." A systems view of the environment was expressed as early as 1869 by John Muir, the California naturalist: "When we try to pick out something by itself, we find it tied to everything else in the universe." The structure of a system tells us about its composition, the kind and size of components. However, equally or more important is the dynamics of the system which tells us how these components interact or interrelate. It is these interactions or interdependencies that make a system different from other collections of objects that are not interacting.

A system may have only a temporary existence as a process of change and have no stability of its own. A pile of logs that have been ignited would be such a system in which the heat produced by the burning of one log causes other logs to start burning. This process accelerates but then quickly terminates in a changed state in which the original pile of logs no longer exists. A homeostatic system has stability because it is able to make adjustments to normal changes in the function of the system that could cause great changes in the system. These homeostatic adjustments move the system back into equilibrium where inputs and outputs are equal. The human body is such a system. For example, if the heat production of the body increases and the body temperature starts to rise, the body is able to make adjustments in its functioning to increase the loss of heat from the body to lower the temperature.

The basic unit of the environment studied by ecologists is an ecosystem, which consists of a community (a group of animals and plants living together in the same area) and the physical habitat of that community (soil, air, climatic factors, etc.) An ecosystem has no specific size, for it can be a small aquarium or a lake, a prairie or a field of wheat, your backyard or the biosphere (the whole living surface of the earth).

One important set of interactions in an ecosystem is that which provides for the transfer of matter and energy in the form of food. A simple pathway of transfer of food is known as a food chain, such as:

Grass → Grasshopper → Prairie Lizard → Racer (snake) → Red-tailed Hawk

However, an ecosystem has more than one food chain. Other animals, in addition to lizards, eat grasshoppers. The series of interconnected food chains in an ecosystem is known as a food web.

Not all relationships in an ecosystem are feeding relationships. Satisfaction of all the needs of an organism usually depend to some degree upon its interrelations with other organisms, whether it be the supply of oxygen maintained by the photosynthesis of green plants or the supply of feathers or hair to line a nest provided by another animal.

The place of a particular species of animal or plant in an ecosystem is its ecological niche. This includes all of its interrelations with other animals and plants, as well as with the physical features of the ecosystem.

Many natural ecosystems are homeostatic systems. They maintain an equilibrium (or a fluctuation about an average state) primarily by an interplay of opposing forces. Because of this homeostatic regulation in the biosphere, the composition of the atmosphere remains stable. The population size of various kinds of animals in an ecosystem remains relatively stable with a dynamic balance of reproduction and mortality factors. Some ecosystems may be transient and unstable and in process of change.

References

For the teacher:

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For students:

1. Allen, Durward L. 1974. Of fire, moose and wolves. Audubon, vol. 76, no. 6, pp. 38-49 (November).
2. Amos, William H. 1959. The life of a sand dune. Scientific American, vol. 201, no. 1, pp. 91-99 (July).
3. Becker, Herman F. 1965. Flowers, insects and evolution. Natural History, vol. 74, no. 2, pp. 38-45 (February).
4. Brander, Robert B. and David J. Books. 1973. Return of the fisher. Natural History, vol. 82, no. 1, pp. 52-57 (January).
5. Ehrlich, Paul R. and Peter H. Raven. 1967. Butterflies and plants. Scientific American, vol. 216, no. 6, pp. 104-111, 113 (June).
6. McMahan, Pamela. 1975. The victorious coyote. Natural History, vol. 84, no. 1, pp. 42-51 (January).
7. Mech, L. David. 1974. A new profile for the wolf. Natural History, vol. 83, no. 4, pp. 26-31 (April).
8. Schaller, George B. 1972. The endless race of life. Natural History, vol. 81, no. 4, pp. 38-43 (April).

Dwight Platt

Module 7: Rhythms in nature

Age level: Elementary school

Subject: Biology **Theme:** Rhythms

Sequence: Pre-field trip **Prerequisites:** None

Objectives: To become familiar with the idea of rhythm and to recognize rhythm as a patterned repetition in time or in space; to become aware that nature has many kinds of rhythms

Time required: 1 to 2 hours; Part I may be done the first day and Parts II and III the second day

Materials required:
Some instrument with which to make a series of rhythmic and arrhythmic sounds (see Part I, #1)
Flowers, twigs with leaves, or other parts of living organisms with a rhythmic structure
Materials needed for activities from Module 10 that are used

Activities

Part I.

1. Ask the class what a rhythm is. After a short discussion, test their recognition of rhythm. Make a series of rhythmic sounds (by tapping with a stick, clapping hands, or using a piano or other musical instrument). Ask if the sounds have a rhythm. Make a series of non-rhythmic or more or less random sounds. Ask if these sounds have a rhythm. Try other series of sounds. For younger children, the sounds should be very regularly rhythmic or arrhythmic, but for older children you can try some more complex irregular rhythms.

   After testing with sounds, have each student feel his/her pulse. Ask them if the pulse is rhythmic.

   Ask the class what makes something rhythmic. How were they able to recognize rhythms? Be sure the point is made that a rhythm doesn't have to be a sound. The pulse is rhythmic, and it was sensed by touch. Help younger children to be aware that rhythm is regular repetition. Older children should be able to understand that rhythm is any kind of organized or patterned repetition as opposed to a random repetition or lack of repetition.

2. Ask the class to suggest rhythms in the environment around them. The students may suggest various types of specific rhythmic phenomena, such as the chirping of a cricket, a bird song, etc. However, lead the discussion to more general environmental rhythms. Be sure that the rhythms of day and night and of the seasons are suggested. Write these two general environmental rhythms on the chalkboard, and under each of these two headings have the class compile two lists:

a. Rhythmic activities of people that are timed to each of the above two environmental rhythms.

b. Rhythmic activities of animals or plants that are timed to each of the above two rhythms.

You may want to briefly discuss how these rhythmic activities are timed. Do people go to bed at night because it gets dark, or because they are tired, or for other reasons?

Part II.

Review the idea of rhythm that has been discussed in Part I. The rhythms that the class discussed so far were rhythms in time. Ask the class if there are repetitions in spatial arrangement that are rhythmic. Adapt some of the activities from Module 10 to acquaint your class with rhythm in spatial arrangement. You may want to use part or all of the slide set, "Rhythms in Art and the Environment," that is mentioned in Module 10.

Show the class (for younger children) or give to each student (for older children) a flower, a twig with leaves, or any other living organism or part of a living organism that has rhythmic structure. Ask them to list the rhythms they observe.

Part III.

Point out to the class that patterned repetition or rhythm is a very common theme in nature and that it would be interesting to explore some of these rhythms in a prairie.

For older children you may want to discuss some other types of rhythms in nature. Two cyclic types of rhythms are:

1. The life cycle of animal generations

   ⟶ egg ⟶ tadpole ⟶ frog ⟶ egg ⟶ tadpole ⟶

2. The cycle of matter in an ecosystem

   ⟶ oxygen in air ⟶ animal ⟶ carbon dioxide in air ⟶ plant ⟶ oxygen in air ⟶

Statement of Concepts

Two definitions of rhythm from Webster's dictionary may be relevant to this module: "Movement or fluctuation marked by the regular recurrence or natural flow of related elements" and "a regularly recurrent quantitative change in a variable biologic process." Two characteristics of rhythm stand out in these definitions--recurrence or repetition and regularity or patterning.

Rhythms are very common in nature--in sounds, in spatial arrangements, in changes in physical conditions, in activity of organisms, in physiological functions, etc. These rhythms generally interact and often reinforce or interfere with one another.

There are a number of very regular general environmental rhythms that are caused by movements of the earth. The day-night cycle and the seasonal cycle are the most obvious. These result in rhythmic changes in physical factors such as light, temperature, humidity, rainfall, etc. Biological rhythms of animals and plants are often in time with these physical rhythms, so that the organism can best adapt to its environment.

Rhythms of living organisms can be simply a direct response to an environmental rhythm. Most biological rhythms have an internal physiological component and this may even control the rate of the rhythm by a physiological timing mechanism or a biological clock. Cycles in nature are a type of rhythm. They involve repetition as the generations continue to repeat the various developmental stages (a life cycle) or as an element like oxygen repeats the same series of chemical reactions and is passed from organism to organism in the same way (matter cycle in an ecosystem). Contrast this cyclic pattern with the linear design common in human systems (see Lopez, 1973).

References

1. Brown, Frank A., J. Woodland Hastings and John D. Palmer. 1970. The Biological Clock--Two Views. New York: Academic Press.

2. Costello, David F. 1969. The Prairie World. New York: Thomas Y. Crowell, pp. 17-35.

3. Lopez, Barry. 1973. In praise of the circle. Environmental Action, vol. 4, no. 22, pp. 8-11 (March 31).

4. Pengelley, Eric T. and Sally J. Asmundson. 1971. Annual biological clocks. Scientific American, vol. 224, no. 4, pp. 72-79 (April).

5. Smith, Robert Leo. 1974. Ecology and Field Biology (2nd edition). New York: Harper and Row, pp. 190-208.

Dwight Platt

Module 8: The beat of nature

Age level: High school

Subject: Biology **Theme:** Rhythms

Sequence: Pre-field trip **Prerequisites:** None

Objectives: To understand the nature of a rhythm as patterned repetition and to recognize that it can occur in either time or space; to understand that rhythms are common in nature, that rhythms occur in the physical environment, and that rhythms may also be maintained by biological clocks in living organisms; to recognize that cyclical phenomena are rhythmic and are an important pattern in nature

Time required: At least 1 hour for activities from Part I on the first day; at least 1 hour for activities from Part II on the second day; if all of the activities are to be done in some detail, you should spread it over 3 days

Materials required:

Examples of natural rhythms such as a twig with leaves, a leaf with evident veining, graphs of daily activity of an animal, graphs of cyclic fluctuations in an animal population, sonograms of bird songs or insect calls, etc. (Some of the graphs can be obtained from ecology textbooks, and sonograms are found in some bird books).

Graph paper

A percussion instrument or some other way of beating out a rhythm

Materials listed in Module 10 for activities selected

Activities

Part I.

1. Ask the class what is meant by "jet fatigue." Point out that it is caused by two rhythms that are out of adjustment--the day-night rhythm in the environment and the 24-hour physiological rhythm in the human body.

   Ask for other examples of rhythms. Encourage a wide-ranging list but do not spend much time discussing them.

2. Discuss what the term "rhythm" means. The discussion will probably center around patterned repetition as an important characteristic. After a short discussion, ask the class to identify which of the following are rhythmic. Briefly discuss in what ways each phenomenon is or is not rhythmic.

   a. Bird migration
   b. Human population growth since 1875
   c. Population growth of the cottontail rabbit since 1875
   d. Flowering of plants in a prairie
   e. Activity of mice in a prairie

3. List the following general environmental rhythms at the top of separate columns on the chalkboard: seasons, moon phases, day-night, and tides. Now ask the class to list under each heading some of the rhythms in physical factors that are caused by each of these general environmental rhythms. These will include such things as light-dark cycle, cyclic changes in photoperiod, temperature cycles, humidity cycles, air or water exposure in tidal areas, etc. Then ask the class to list some biological rhythms that are timed to these general environmental rhythms.

   Discuss with the class how these biological rhythms are controlled. Some hypotheses that might be suggested are:

   a. The biological rhythms are direct responses by the organism to the physical environmental rhythms (birds may go to roost in the evening when the light intensity gets low).

   b. The biological rhythm is an internal function of the organism but the rate is determined by the environmental rhythm (each year, frogs have a reproductive cycle of producing and maturing eggs but will only become reproductively active and lay eggs when environmental conditions are right).

   c. The biological rhythm and its general rate is maintained by an internal biological clock which is periodically timed to remain in synchrony with the environmental rhythm (a mouse kept in continuous dark will continue its 24-hour cycle of activity and inactivity, but it may gradually get out of phase with the light-dark cycle outside).

   How can these hypotheses be tested? Assign to each member of the class one of the biological rhythms in the lists compiled on the chalkboard by the class. Ask each student to design an experiment to test the applicability of one of the above hypotheses to the assigned rhythm. Point out to the class that all of these hypotheses may be correct, and different rhythms may have different causal mechanisms.

4. Assign some members of the class to read the suggested sections in Costello (1969) and in Weaver (1954) and the articles by Palmer (1971), by Lopez (1973), and by Pengelley and Asmundson (1971), and to report on their reading to the class (see references at the end of the module).

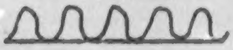
Part II.

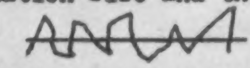
1. Review the nature of rhythms as discussed in Part I. Have a few students report on the experiments they have designed (assignment in Part I, #3). Discuss with the class the nature of a good experiment. Have all of the class members turn in their experimental designs.

   Ask for reports on the assigned readings in Costello (1969), Weaver (1954), Palmer (1971), and Pengelley and Asmundson (1971), and discuss each with the class.

2. Point out to the class that rhythms can occur in space as well as in time. A series of sand dunes is such a rhythm. The alternation of plant communities on the dunes and the lowlands between them is another rhythm. Select some of the activities from Module 10 to illustrate rhythms in space.

3. Give to each member of the class an example of a natural rhythm and a sheet of graph paper (see section on materials required). Now ask each student to draw a series of curves on the graph paper that illustrate the rhythm. Assign a standard maximum height and average width to the curves so that they will be comparable.

Examples: a. For a twig with leaves, the curves would all have a common base line. The height of each curve would be proportional to the length of the leaf, while the distance between the peaks of the curves would be proportional to the distance between leaves: 

b. For population fluctuations, the curves would go both above and below the average population size, with the height of the curve representing population size and the horizontal distance representing time: 

After the curves have been drawn, have each student beat out the rhythm with the loudness of the beat representing the height of the curve and the time between beats representing the space between peaks. For curves that go both above and below the line, you can have them beat out an alternating rhythm with curves above the line being a beat of a higher pitch than curves below the line. A stick or fingers on the desk, a toy xylophone or some percussion instrument can be used for beating out the rhythm. Post the graphs of the rhythms on a bulletin board.

The class should note that none of these rhythms are exactly regular, but they also are not simply random beats. Point out to the class that patterned repetition is a predominant theme of biological organisms, but that repetition is seldom precisely regular except in those rhythms made by man. Point out that most change in nature occurs as rhythmic fluctuations. Linear or directional change is usually limited or very slow (evolutionary change or long-term climatic change). Rapid directional change is often catastrophic.

4. Ask for the report on the article by Lopez (1973). Discuss it with the class. Point out that an important pattern in nature is cyclic repetition. Have the class diagram on the chalkboard an example of a life cycle of an organism, the water cycle, and the cycle of a chemical element in an ecosystem. Contrast these diagrams with a diagram of the production, use, and disposal of non-returnable containers. Note that there are a source and a disposal site that are changing in the diagram of linear flow. Why are cyclic patterns so common in nature? Can you observe rhythm in cyclic patterns? Why are linear patterns so common in human systems?

5. Introduce the idea of a field trip to study rhythms in a prairie.

Statement of Concepts

Two definitions of rhythm from Webster's dictionary may be relevant to this module: "Movement of fluctuation marked by the regular recurrence or natural flow of related elements" and "a regularly recurrent quantitative change in a variable biologic process." Two characteristics of rhythm stand out in these definitions--recurrence or repetition and regularity or patterning.

Rhythms are very common in nature--in sounds, in spatial arrangements, in changes in physical conditions, in activity of organisms, in physiological functions, etc. These rhythms generally interact and often reinforce or interfere with one another. The example of "jet fatigue" given in the module is one where rhythms are out of adjustment. Traveling long distances very rapidly by jet airplane causes physiological stress because the timing of the environmental rhythm of day and night no longer matches the 24-hour physiological rhythm in the human body.

There are a number of very regular general environmental rhythms that are caused by movements of the earth or other heavenly bodies. The most important of these are listed in the module. These result in rhythmic changes in physical factors such as light, temperature, water availability, oxygen availability, etc. Biological rhythms are often in tune with these physical rhythms so that the organism can best adapt to its environment. You will probably have no trouble thinking of biological rhythms related to the daily and seasonal cycles. The tidal cycle is very important in the patterns of activity and patterns of physiological change (such as the metabolic use of oxygen) for animals living in the tidal zone. The moon phases affect the height of the tides and so have been shown to be important in timing the reproduction of some marine organisms such as the annelid palolo worm. The moon phases also cause changes in the amount of light at night, and this may affect the activity of mice or the singing of the mockingbird at night. Also, the period of moon phases may be related to some other biological cycles such as the menstrual cycle. There are many human cultural cycles that had their origin as a response to the regular cycle of moon phases.

Rhythms of living organisms can be simply a direct response to an environmental rhythm. If a person is asked to strike a note on a piano each time he sees a light flash, he will produce a rhythmic series of sounds in time with a rhythmic pattern of light flashes which he has seen; but there is no internally controlled or endogenous component of this rhythm. Most biological rhythms have an internal physiological component, and this may even control the rate of the rhythm by a physiological timing mechanism or a biological clock. These rhythms will be maintained even in the absence of any clues of environmental rhythms. However, normally there must be timing mechanisms so that the physiological mechanism can be adjusted to coincide in time with the environmental rhythm. Often the timing mechanism involves the most regular environmental clues of the rhythm. Many organisms time their seasonal cycles by the regular changes in photoperiod rather than the more irregular or variable changes in the temperature or rainfall. You may want to read the section on biological clocks in a biology textbook or the book by Brown, Hastings, and Palmer (1970) to obtain more background.

Although some of the general environmental rhythms are regular, the rhythms in physical factors which accompany them and the biological rhythms are usually quite irregular or variable. This is also true of rhythms in spatial relationships and other types of rhythms in nature. This introduces variety into the rhythmic pattern. Much of the change that occurs in nature is a part of this rhythmic pattern. Change which continues to progress in a linear fashion is usually limited (examples are growth or ecological succession) and/or occur very slowly (examples are evolutionary change or general climatic change). Rapid and sustained linear change in nature is usually catastrophic.

Cycles in nature are a type of rhythm. They involve repetition as the generations continue to repeat the various developmental stages (a life cycle) or as an element like oxygen or nitrogen repeats the same series of chemical reaction and is passed from organism to organism in the same way (matter cycles in an ecosystem). Read the article by Lopez (1973) to contrast the linear design common in human systems.

The activities in this module should give students experience with hypotheses and the designing of experiments to test hypotheses. Be sure to emphasize the nature of experimental design, the difference between the experimental group and the control group and the necessity to have large enough sample sizes.

References

1. Brown, Frank A., J. Woodland Hastings, and John D. Palmer. 1970. The Biological Clock--Two Views. New York: Academic Press.

2. Costello, David F. 1969. The Prairie World. New York: Thomas Y. Crowell, pp. 17-35.

3. Lopez, Barry. 1973. In praise of the circle. Environmental Action, vol. 4, no. 22, pp. 8-11 (March 31).

4. Palmer, John D. 1971. The rhythm of the flowers. Natural History, vol. 80, no. 7, pp. 64-73 (August-September).

5. Pengelley, Eric T. and Sally J. Asmundson. 1971. Annual biological clocks. Scientific American, vol. 224, no. 4, pp. 72-79 (April).

6. Weaver, J. E. 1954. North American Prairie. Lincoln, Nebraska: Johnson Publ. Co., pp. 123-133.

Robert Regier

Module 9: Understanding structural diversity

Age level: Junior high

Subject: Art **Theme:** Diversity

Sequence: Pre-field trip **Prerequisites:** None

Objectives: To introduce the concepts of diversity and structure; to show that one form of diversity (variety) in our environment is in its differing structures; and to prepare the group for a field trip to a specific setting for the purpose of discovering structural differences and similarities in nature

Time required: Activity related to this module could span an entire week or more, though only 2 or 3 full class periods might be used

Materials required:

Slide set #5: "Understanding Structural Diversity" (available on loan from SKEEC)
Old magazines, particularly those with numerous photos including photos from nature
9" X 12" construction paper in two contrasting colors
Rubber cement or Elmer's glue
Scissors
Pencils
Unruled notebook paper or other drawing paper
Masking tape and/or pins

Investigation

The investigation in this module is designed to generate interest in the concepts of diversity and structure prior to an actual exploration of a natural setting. However, the suggested activities could be used even if a follow-up field trip is not planned.

Presentation, Part I. The value and possibility of extended discussion will likely vary from group to group. Assuming that some discussion is possible and useful, one might open the subject by stimulating some thought on the consequences of sameness: What if everyone in the class had identical backgrounds? the same interests? the same skills? the same clothes? What if everyone's home and street looked exactly alike? What if the activity in every hour of the school day was the same? These questions are only suggestive. The intent is to encourage students to imagine an environment of sameness and how such an environment would affect behavior and a sense of well-being.

A discussion on sameness could be followed with a similar series of questions focusing on differences, or variety: What does variety do for us? Can there be too much variety? Variety throughout the school day may be desirable, but what if each school day had a different scheme of organization for an entire year so that no two days had a similar pattern? What would the effects be on a teacher? on the students?

The discussion could conclude with several observations about the interrelationship of similarities and differences. Help the group to be alert to this interplay; for example, in their daily living patterns, their man-made environment, the natural environment, and in art. Variety within unity (differences within sameness) should be identified as a design principle.

Activity, Part I. The purpose of this activity is to reinforce the concepts of diversity and similarity.

Picture Gathering

Using home supplies of magazines as a resource, have the group find visual examples of patterns of sameness in their environment. Examples might be such images as a street of similar or identical houses, a one-crop field, a building facade with a uniform grid pattern of windows, or a large black-top parking lot. Encourage them to also look for examples of extreme diversity such as groups of unrelated commercial signs, unplanned areas that border towns and cities, crowded window displays, or cluttered newspaper ads.

Organize an area in a room where these images of sameness and differences can be grouped. Encourage the group to consider how some of these situations might be more effective if more differences were introduced in some, and more sameness introduced in others.

This activity could be enhanced if some members of the group have their own cameras and the picture gathering would be spread over a span of a week or more. This would allow those with cameras to supplement the magazine photos with their own photos of situations found near at hand.

Design Exercise

Supply each person with 4 or 5 sheets of 9" X 12" construction paper. Use 3 of the sheets as backgrounds for three different arrangements. These 3 sheets should all be the same color. The additional sheets should be a different, contrasting color. Have each member of the group cut their contrasting colored sheet into simple shapes as needed for the development of the three arrangements.

The first arrangement should be a visual representation of sameness. For example, same-size circles could be arranged in an evenly spaced grid pattern. Be sure to discourage individuals from using representational shapes for this first step, as well as for steps 2 and 3. Simple geometric shapes would be adequate. Representational shapes such as people, animals, etc. make the exercise needlessly complex.

The second arrangement should be a representation of a high degree of difference. Encourage everyone to introduce as much difference as possible into the arrangement. This would be done by varying size, the kinds of shapes, and placement.

The third arrangement should be a modification of the first two arrangements, so that an interplay between sameness and difference is demonstrated. If the first arrangement would be selected for modification, the problem would be to decide how to introduce more diversity without eliminating all the similarities already present. If the third arrangement would be selected, the problem would be to reduce the high degree of differences so that some sameness would be felt.

The results should be displayed by sets and discussed. Which ones best illustrate the design principle of "variety within unity?"

This exercise could be stopped at this point or modified and continued if there is time or interest. For example, one could attempt another composition with only one variable, such as spacing. The size and shape of each unit would be constant. Such explorations could sensitise a student to some of the more subtle dimensions of variety.

Variety appears to be effective only when it functions within limits (sameness). It can be instructive to explore how severe these limits can be before visual boredom prevails. If you have access to a slide file of contemporary abstract painting you could conclude this exercise by selecting and projecting paintings that illustrate subtle variations within very constant patterns. A likely source for these kinds of paintings would be in the work of such op painters as Bridget Riley, Richard Anuskiewitz, or Victor Vasarely.

Presentation, Part II. Offer a simple definition of structure (see Statement of Concepts). Mention or show pictures of several forms in nature, such as a spider web, honey comb, leaf, or fish and ask how one might describe their structures. With this discussion as background, show slides 1 through 5 from slide set #5, "Understanding Structural Diversity." Explain that the five structures illustrated represent one of the dimensions of diversity in nature. Nature contains not one structure, but many structures; and each type of structure is repeated many times with variations.

Activity, Part II. Have each person draw the structures as they are projected so that familiarity is increased and they have their own visual notes to which they can later refer. Next to each drawing have them list forms in nature that they think contain the structure the drawing illustrates.

Picture Gathering

Assuming that the photographic resources used in Part I are still available, ask the group to find illustrations of as many of the five structures as they can. These illustrations could include both natural and man-made forms. This investigation can be stimulated by projecting slides 6 through 15 from set #5, "Understanding Structural Diversity." These slides show two examples of each structure, one from nature and one in a man-made form. The projection of these slides provides a good opportunity to highlight what the slides already imply, that in many instances man designs after nature by adapting the same structures found in nature.

The search for examples of the five structures need not be confined to magazine pictures. Again, those with cameras might want to use this means to "capture" the structures. Actual objects around the home, natural or man-made, could also be brought in if they illustrate one or more of the structures. However, when searching for examples, everyone should be reminded to consider the very large pattern as well as the small object. Aerial views of radiating street patterns or branching river patterns are as effective as flowers or leaves.

If good examples of both natural and man-made structures are brought in, it might also be helpful to encourage individuals to see if they can identify any characteristic differences in the way the same structures appear when found in a man-made form as opposed to a natural form.

Field Trip Preparation. Now that the group has some acquaintance with the concept of structural diversity, motivation for their up-coming first-hand search for structure in a specific natural setting could be stimulated by showing slides 16 through 30. These slides are descriptive of the prairie setting that will be the focus of the field trip. The slides already illustrate some of the structural diversity they will likely encounter. Have the group spot and identify some of these structures as the slides are projected. While viewing the prairie landscape on slides, the group could also apply the concept of diversity in other ways. Other than structure, how else is diversity illustrated? How would one point out the principle of diversity within similarities?

If a field trip is not possible, one could intensify the picture gathering section under Activity, Part II by asking the group to sketch the structural forms in nature that they find in their own yards, in nearby parks, or around the school.

Statement of Concepts

Diversity. Diversity is the condition of having or noting differences. A synonym for diversity more commonly found in art-design vocabulary would be "variety." Either of these two terms could be used throughout this module. Diversity can be best understood if discussed in relation to its opposite--similarity or sameness. Nature demonstrates an interplay of similarities and differences (see Module 1, Statement of Concepts). Sometimes this natural interplay is altered and only sameness is apparent, such as in one-crop farming. In man-made environments such as the fringe areas around cities, similarities are so obscure that only differences may seem apparent.

Whether man-made or natural, environments that fail to have a healthy interplay between differences and similarities tend to be unstable. A disease, for example, could more easily destroy a biological community without adequate diversity. A human environment without adequate similarities is perceived as fragmented and disorganized, and thus an undesirable place in which to live. In art and design, diversity within similarities also appears to be the most satisfying option, perhaps not only for the sake of stability, but because such a relationship avoids both visual boredom and visual chaos. Boredom and chaos are equally ineffective in sustaining visual interest and vitality. Design texts sometimes state the interrelationship of similarities and differences with the phrase, "variety within unity." (Anderson, 1961: 48-49)

Many of the differences and similarities in nature are quite obvious, such as different kinds of trees or similar colors. This module is designed to create awareness and appreciation of one of the less obvious aspects of diversity in nature--structural diversity.

Structure. Structure refers to a pattern of organization, the way in which the parts of something relate to each other and to the whole. Forms in nature, such as seed pods, flowers, trees, etc. all have patterns of organization, but the patterns differ. The patterns of organization (structures) in nature that are to be investigated in this module are radial patterns, spiral patterns, modular patterns, branching patterns, and skeletal patterns. A brief description of each follows:

1. Radial patterns (slide 1) - linear elements that move out in multiple directions from a central core.

2. Spiral patterns (slide 2) - linear movement outward from a central core in a spiraling, circular direction.

3. Modular patterns (slide 3) - repetition of a similar unit in any direction.

4. Branching patterns (slide 4) - linear elements that subdivide as they become more extended.

5. Skeletal patterns (slide 5) - branchings connected to a main stem by a series of joints.

References

1. Anderson, Donald M. 1961. Elements of Design. New York: Holt, Rinehart and Winston, pp. 48-49.

Robert Regier

Module 10: What is rhythm?

Age level: Junior high

Subject: Art

Theme: Rhythms

Sequence: Pre-field trip

Prerequisites: None; Modules 14 and 47 would provide helpful background for developing an awareness of rhythm as an interdisciplinary concept

Objective: To understand rhythm as a visual concept in art and in nature

Time required: 2 or 3 sessions

Materials required:

Old magazines that are useful as picture resources
Construction paper in two contrasting colors
Library paste or Elmer's glue
Scissors
Masking tape and/or pins
Slide set #6: "Rhythms in Art and the Environment" (available on loan from SKEEC)

Investigation

The investigation in this module is designed to develop an understanding of rhythm as a visual concept. This should be regarded as a preparatory step for a field trip to the natural prairie for the purpose of identifying rhythmic features within the prairie environment. However, the suggested activity could be used even if a follow-up field trip is not planned.

Getting Started. The concept of rhythm could be introduced in a number of ways. One might simply ask for definitions or examples. The responses might likely relate to sound or movement rather than to visual experience. Those with musical backgrounds should be able to demonstrate a rhythm if not explain it. One could ask for demonstrations of non-rhythmical sounds as well as rhythmical sounds. What is the difference between a group clapping hands randomly and clapping according to a measured beat? This opening discussion could be wide ranging. If it drifts away from visual experience, one finally needs to volunteer some of the ingredients of a visual rhythm, stressing particularly the need for repetition of a unit, and some pattern or regularity in the repetition. Before dropping the discussion, try to alert them to the all-pervading way rhythm is present in our own life processes and in our natural world.

Visual Research. The discussion could be reinforced by showing and discussing the first 11 slides. The group could be encouraged to find additional pictures that express rhythms in man-made forms, nature, or in art. These could be displayed so that the consciousness of rhythm as a natural process and an aesthetic dimension grows. Small rhythmic objects around the home, natural or man-made, such as a comb, piece of patterned cloth, a shell, etc. could be brought in and displayed. It would be instructive to sort the pictures and objects according to regular and irregular rhythms. This division would likely separate the natural from the man-made objects.

Rhythm Exercise. Give each person a 6" X 9" piece of construction paper and eight strips of paper of a contrasting color that measure 1/4" X 3". Ask them to arrange these in a rhythmic way. This will test their perception of rhythm. Do the compositions illustrate a "beat," an accented pattern? Discuss the results. If there are some attempts that fail to be rhythmic, try to identify the problem. Now give each person two additional 6" X 9" sheets of paper and access to an unlimited number of 1/4" X 3" strips. Have them make two more rhythms, one regular and one irregular. Give them the freedom to cut any number of strips to lengths shorter than 3" so that length of line as well as spacing between lines can be a variable in the compositions.

Edmund Feldman (1967:267-268) identifies four kinds of rhythm, three of which are relevant to this exercise. They are repetitive rhythm, alternative rhythm, and progressive rhythm (see Supplement #1). How many of the exercises can be grouped according to these general types? If you wish to share these types with the class, they are illustrated on slides 12, 13 and 14.

Assessment. Display a large number of rhythm exercises. Which ones are more interesting? Why? Does it have to do with regularity or irregularity, complexity or simplicity, obvious or subtle variations? Can the group think of natural parallels to the rhythms they designed? Do some look like rows of trees, skeletons, waving grass, seed arrangements, etc? Let them know that this exercise will be followed by a field trip to the natural prairie for the purpose of finding as many variations of visual rhythms as possible.

Field Trip Preparation. Slides 15 through 25 are descriptive of the natural prairie which they will visit. Not all the pictures illustrate obvious rhythms, though rhythms that they do illustrate could be pointed out. The purpose of the slides is primarily motivational, rather than descriptive of rhythm. Ideally, they should be shown the day prior to the field trip.

If the field trip is not possible, the Visual Research and Rhythm Exercise sections would still be of value. One could compensate for the absence of the field trip by intensifying the search for small rhythmic objects, placing more emphasis on natural objects that could be found in the yard.

Statement of Concepts

Rhythm is ebb and flow, action and repose. Our own bodies provide the best illustration of this. The heart beat, breathing, and walking are all examples of rhythm. On a larger scale, day and night, and the cycle of the seasons illustrate natural rhythmic patterns. The examples cited all depend on repetitive elements for their rhythmic quality, but rhythm is not synonymous with repetition. A lawn covered with fallen leaves is repetitive, but not necessarily rhythmic. A large flock of blackbirds in flight (slide 1) is repetitive but rarely rhythmic. However, geese or pelicans in flight (slide 2) form a repetitive configuration that is immediately perceived as rhythmic because of the sense of pattern exhibited by a degree of regularity in the relationship of one unit to another. Elements that are repeated must have a perceived sense of order or pattern before they function rhythmically. So rhythm could also be defined as patterned or accented repetition.

Rhythm is considered to be one of the basic design principles. Feldman (1967:267) defines rhythm as "the ordered or regular recurrence of an element or elements." Feldman's definition might be strengthened by inserting the phrase "more or less regular," because the fundamental difference between natural rhythms (except for crystal structure) and many man-made rhythms has to do with the degree of regularity. The rhythm of a flight of geese is apparent because of the more or less regular pattern, but the geese obviously do not exhibit precise regularity. For absolute regularity we would need to turn to man-made forms such as the regularity of windows on the facade of a skyscraper, or printed patterns on wallpaper or linoleum. The lack of exact regularity in natural rhythmic patterns is the feature that often prevents boredom. It is man's tendency to eliminate irregularity that frequently causes a rhythmic pulse to be tedious and dull rather than alive and interesting. For a comparison of rhythms with regular and irregular patterns, view slides 3 through 8.

The visual artist is interested in rhythm for at least two important reasons--unity and movement. Rhythm, because it depends on repetition, is an effective unifying element. An element repeated within a composition strengthens the sense of unity it has. Repetitions which are patterned (rhythmic) create a stronger sense of unity than does unpatterned repetition.

Action and repose is always a facet of rhythm. Visually, this could be illustrated in a variety of ways. Dots and the spaces which separate them, a series of longer and shorter lines, or a sequence of alternating colors all express the pulsating quality of action and repose. The eye naturally and easily follows the development of a pulsating sequence and so a rhythmic pattern moves the eye more quickly across a visual field than the eye would move if no rhythmic pattern were present. Thus, rhythm creates a sense of movement, particularly if an oblique line is used as part of the rhythmic unit.

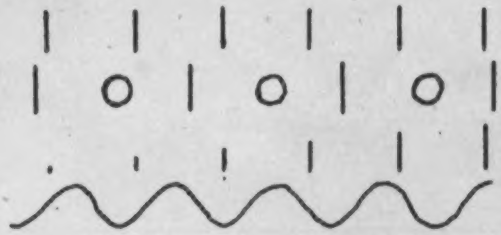
Slides 9, 10 and 11 illustrate three paintings in which the artist used rhythm as a means for strengthening the sense of movement or unity. "Seven Jellied Apples" by the American painter, Wayne Thiebaud, illustrates a simple and obvious use of rhythm for unifying a composition. The famous painting, "Nude Descending a Staircase" by Marcel Duchamp, exploits rhythmic repetitions as a means for creating a sense of movement. In an attempt to focus on movement as his subject rather than the clear shape of the figure, Duchamp's painting was termed "scandalous" in the New York Armory Show of 1913. The Dutch painter, Piet Mondrian, exploited the rhythmic beat in quite a different way to convey the movement he sensed in the heart of a city in his painting titled "Broadway Boogie Woogie." Rhythm is an important compositional feature in many forms of art, including architecture.

Reference

1. Feldman, Edmund. 1967. Art as Image and Idea. Englewood Cliffs, New Jersey: Prentice-Hall, pp. 267-268.

Module 10: Supplement #1

Types of rhythm:[1]
A. Repetitive
B. Alternative
C. Progressive
D. Flowing



The above types could have either regular or irregular characteristics.

Statements on rhythm:

1. An ebb and flow, a recurring cycle.[2]
2. Repetition with emphasis.[2]
3. In design as in nature, the underlying principle is rhythm.[2]
4. Accented repetition.[3]
5. Directional movement or progression, created by a pattern of strong and weak impulses.[3]
6. The ordered or regular recurrence of an element or elements.[1]
7. A continuance, flow, or feeling of movement achieved by the repetition of regulated visual units--"a beat."[4]
8. Alternation of optical similarities.[5]
9. Once a rhythm is recognized, a dynamic unity is formed.[5]
10. Rhythm leads the eye from one area to another in direct, flowing or staccato movement.[6]
11. A measured succession of accents and intervals.[6]
12. Regularity and recurrence which lead to expectancy.[7]

References

1. Feldman, Edmund Burke. 1973. Varieties of Visual Experience. New York: Harry N. Abrams, pp. 340-342.
2. Bevlin, Marjorie Elliott. 1970. Design Through Discovery. New York: Holt, Rinehart, and Winston, p. 50.
3. Harlan, Calvin. 1970. Vision and Invention. Englewood Cliffs, New Jersey: Prentice-Hall, p. 13.
4. Ocvirk, Bone, Stinson, and Wigg. 1968. Art Fundamentals. Dubuque, Iowa: Wm. C. Brown, p. 24.
5. Kepes, Gyorgy. 1961. Language of Vision. Chicago: Paul Theobald and Co., p. 53.
6. Baldinger, Wallace S. 1960. The Visual Arts. New York: Holt, Rinehart, and Winston, p. 34.
7. Evans, Helen M. 1973. Man the Designer. New York: Macmillan, p. 58.

Dwight Platt

Module 11: Sand Prairie Natural History Reservation

Age level: Can be adapted for all age levels, elementary through adult

Subject: Biology

Sequence: Pre-field trip

Prerequisites: None, except an understanding of the concept of natural community; this module can be used most effectively just before a field trip to a prairie

Objectives: To introduce the prairie as a grassland, but one which includes a diversity of animals and plants; to introduce Sand Prairie Natural History Reservation and some of the habitats on this area

Time required: 1 hour

Materials required:
Slide set #7: "Sand Prairie Natural History Reservation" (available on loan from SKEEC)
Map by Küchler (1974) of "The potential natural vegetation of Kansas" (available on loan from SKEEC)

Activities

Consult Allen (1967), particularly the first chapter, "Empire of the sun," before leading the discussions in this module. You may want to assign this chapter to be read by older students.

1. Ask the class: What do you think of when you think about the prairie? Get responses from as many as wish to respond. Summarize these responses and then ask the class if one of the important things that can be said about a prairie is that it is a grassland.

2. Now ask: What is a grassland? It is a plant community dominated by grass.

   Is a field of wheat a grassland? How does a field of wheat differ from a prairie? From the discussion of these two questions you will be able to add to the definition of a prairie that it is a grassland with many different kinds of grasses, with many different kinds of broad-leafed flowering plants called forbs, and even with a few shrubs and trees.

3. Now ask: Is a pasture a grassland? How does a pasture differ from a native prairie? From the discussion of these two questions, you will be able to add the animal community to the definition of a prairie. The pasture differs from a native prairie in that the numbers of large grazing animals are greater, they graze more constantly on a single area, and the large grazing animals in a pasture are of different kinds than in a native prairie. Point out that these differences in the animal community may have an effect on the plants in the grassland.

4. Discuss the different kinds of prairies in North America, particularly focusing on the tallgrass prairie, the mixed-grass prairie, and the shortgrass prairie. You may want to show the map on pages 52-53 in Allen (1967) and the map by Küchler (1974). Ask the class what was the typical kind of prairie in the locality where they live. For younger students, the discussion should be very general, simply introducing the idea of different kinds of prairie. For older students, you should discuss some of the differences in kinds of plants and kinds of animals in these prairies and some of the differences in climate that determine their distribution. Also point out that there are prairies of different types on other continents of the world.

   Ask the students to find out all they can about the prairie that was found in the local area when European people first arrived. This can be a continuing assignment while you are studying the prairie and you should give the students opportunities to report information that they find.

5. Announce to the class that they will visit a prairie if you have not done so before. Point out to the class that on any one prairie there are different plant communities or habitat types related to the topography (as it affects water availability, light exposure and/or temperatures) and to the soil types. Use slide set #7, "Sand Prairie Natural History Reservation," to introduce the various habitat types related to topography on the Sand Prairie Reservation.

6 (optional). Give as reading assignments one or more of the student readings listed in the references at the end of the module.

Statement of Concepts

A prairie is a grassland, a land dominated by grasses. However, it is a diverse grassland with many different kinds of grasses. Other plants are also important components of a prairie--the forbs (broad-leafed flowering plants) and even a few cacti, shrubs, and trees. The prairie also has a characteristic group of animals, including both plant-eaters and meat-eaters (for a description of typical kinds, see Allen, 1967).

Ecologists recognize three kinds of prairie in the central part of North America--the tallgrass, mixed-grass, and shortgrass prairies. They differ in the kinds of grasses and other plants and some of the animals that characterize them (Allen, 1967). The distribution of these kinds of prairies is primarily related to climatic factors, particularly water availability and temperatures.

On each prairie there are differences in the plant community caused by differences in topography or soils. These different types of habitats will also have some different animals associated with them.

References

Background reading for teacher or older students:

1. Allen, Durward L. 1967. The Life of Prairies and Plains. New York: McGraw-Hill, pp. 8-167.

2. Costello, David F. 1969. The Prairie World. New York: Thomas Y. Crowell.

3. Küchler, A. W. 1974. A new vegetation map for Kansas. Ecology, vol. 55, no. 3, pp. 586-604.

4. Sperry, Theodore M. 1971. The Kansas prairie: pre-history of Crawford County. The Midwest Quarterly, vol. 12, no. 3, pp. 271-287 (April).

Student reading assignments:

Advanced junior high and high school

1. Brewer, Richard. 1970. Death by the plow. Natural History, vol. 79, no. 7, pp. 28-35, 110 (August - September).

2. Madson, John. 1970. The prairie blizzard. Audubon, vol. 72, no. 2, pp. 54-56, 65 (March).

3. Madson, John. 1972. The running country. Audubon, vol. 74, no. 4, pp. 4-19 (July).

Elementary grades and lower junior high

1. Anonymous. 1974. Life on the prairie. Ranger Rick's Nature Magazine, vol. 8, no. 2, pp. 17-22 (February).

2. Heady, Eleanor B. 1971. The wonder of grass. Ranger Rick's Nature Magazine, vol. 5, no. 3, pp. 7-10 (March).

3. Heady, Eleanor B. 1971. Grass feeds the animals (part two). Ranger Rick's Nature Magazine, vol. 5, no. 6, pp. 41-47 (July).

Dwight Platt

Module 12: My response to the prairie

Age level: Can be adapted for all age levels, elementary through adult

Sequence: Field trip; can be used as a first experience in a prairie for a class or can be used later after some study of the prairie

Prerequisites: None

Objective: To have an intimate experience of the prairie that will result in a personal response involving feelings and impressions as well as ideas

Best time of the year: Any time when the weather will be comfortable

Time required: At the discretion of the teacher

Materials required: None

Activities

Procedure A (for high school students and adults):

Preparation for this field trip is very important because it requires that the participants be highly motivated. Some groups will require little preparation because most members of the group already have a strong appreciation for this type of activity. On the other hand, it may be very difficult to prepare some groups for a successful field trip of this type. Preparation should be planned to arouse curiosity and interest in and appreciation for the prairie.

1. Quotations about the prairie and pictures can be posted on the bulletin board in the classroom.
2. Descriptive passages about nature can be studied to note the detailed observations and descriptions. Some descriptive passages about the prairie can be found in Madson (1972) and Leopold (1949).
3. Interesting plants and animals can be brought into the classroom to study intimate details of color and shape.

Before the field trip, prepare a student study sheet and duplicate enough copies to have one for each student. You can adapt material from Supplement #1 for your study sheet.

Each student should take a notebook to the prairie to record his/her observations. After arriving at the prairie, gather the group together and spend some time quieting down, if necessary, before sending them out into the prairie. Hand out a student study sheet to each student and have him/her read it. Emphasize the purpose of the exercise by commenting on the instructions found on the study sheet. Point out that students will not see something new in the prairie but hopefully will see something familiar in a new way and with a greater depth. Show poison ivy to the group and warn them to stay away from it.

For groups that are highly motivated, you can leave the situation unstructured and let them observe, respond, and interact as they will. However, for groups with less motivation, there should be some rules that are strictly adhered to:

1. Each person is to stay by him/herself and not disturb anyone else.
2. There is to be no talking with anyone else except the teacher.
3. There is to be no running; only walking.
4. Everyone should stay within a designated area.

Set a time for concluding the activity and, if necessary, a signal for calling the group together. Do not go over 1/2 hour for younger students or those less motivated. Some groups, however, can easily use 1 hour or more for this activity. It is better to stop the activity while students still feel interested and involved.

Procedure B (for junior high students; read Procedure A):

Procedure A can be used, but the students should not be given more than 1/2 hour to work alone. The student study sheet should include only those activities that involve concrete types of observations and responses. The instructions should be shortened and simplified. For younger junior high students, it may be better to give them short assignments from Supplement #2 (as for older elementary students).

Procedure C (for elementary students; read Procedure A):

For older elementary students, prepare short assignment sheets from Supplement #2. Give them the general instructions orally when you first arrive in the field. Then let each student choose the assignment sheet with which he/she wants to work. Tell them they can spend all their time working with one assignment sheet or they can come back to you to get another assignment sheet.

For younger students, the activity should be done as a class. Adapt some of the questions from Supplement #2 to focus their observations of the prairie around them and encourage their observations and response.

References

1. Leopold, Aldo. 1949. A Sand County Almanac. New York: Oxford University Press.
2. Madson, John. 1972. The running country. Audubon, vol. 74, no. 4, pp. 4-19 (July).

Further ideas for this type of activity can be obtained from:

1. Van Matre, Steve. 1972. Acclimatization. Martinsville, Indiana: American Camping Association.
2. Van Matre, Steve. 1974. Acclimatizing. Martinsville, Indiana: American Camping Association.

Module 12: Supplement #1
Student Study Sheet (High School and Adult)

My Response to the Prairie

To the teacher: Select and adapt from this sheet to prepare a study sheet for your class.

As persons, we are continually interacting with our environment on many levels. We can analyze on the rational level in terms of ideas and concepts. However, we can also respond to the environment on the level of feelings and impressions. We learn to understand our environment and to predict how it will work by rational analysis. But without feelings and subjective response, life would lose its richness and we would miss some of its deeper meaning.

This experience on the prairie is to be a personal one as you respond to and interact with the prairie on the level of feelings and impressions. Use this sheet as a guide, but do not feel bound by it. Feel free to follow your own thoughts and feelings. Come back to the sheet only to suggest new paths to try if you reach a dead end. This sheet is to help you to more intimately observe and experience the prairie.

Record your observations and feelings and your response to this experience in your notebook. This is your private record of the experience and you do not need to share it unless you wish to. You may not have names for many of the things you observe--use symbols, descriptions, or sketches. You may want to write a poem or sketch a drawing in response to the prairie. This is fine.

Approach the prairie with your mind wide open. Make use of both positive and negative feelings in experiencing and responding to the prairie.

Now find a comfortable place to pause and quiet down for a few minutes. You may sit or walk around, as you wish.

Do you find things in the prairie that symbolize qualities or feelings?

What represents tallness? shortness?
bigness? smallness?
strength? weakness?
beauty? ugliness?
power? powerlessness?
contentment? annoyance?
love? hate?
good? bad?

Do you see other symbols?

Try to experience the prairie more intimately. Listen. How many sounds can you hear?

Listen for the soft sounds as well as the loud ones.
Are some of them musical? Are some of them noisy?
Describe some of them.
Do they convey any feelings to you? Describe those feelings.
Was the maker of the sound trying to communicate something? What do you think it might be?

Your sense of touch allows you to experience surfaces. How many different kinds of surfaces can you feel? Feel edges too.

Are there soft surfaces? harsh surfaces?
rough surfaces? smooth surfaces?
cool surfaces? warm surfaces?

Do some surfaces feel pleasant? Do some surfaces feel unpleasant?

The chemical nature of your world can be experienced by your sense of smell. Smell some of the objects around you in the prairie. You may want to crush little pieces of leaves or other objects and then smell them.

Smell the surface of the soil.
the grass litter.
some of the plants.

Do you like some smells? Do you dislike some smells?

How many colors can you see on the prairie? Look over the broad landscape. Now focus on the minute parts of those components of the prairie right around you. List the colors that you see.

How many of these colors had you seen before you began to look closely for color?
What was your general impression of the color of the prairie?
How different would your experience in the prairie be if everything were one shade of green?
How different would your experience of the prairie be if your eyes were not sensitive to different colors?

What shapes and forms do you see in the prairie? Look out across the expanse of prairie at the large shapes. Then look at the small and minute.

Where do you find straightness?
curves?
spirals?
circles?
ovals?
waves?
Do you see other shapes?
What kinds of motion do you see?

After experiencing the prairie more intimately, think about your interpretation and responses.

What characterizes	bigness?	smallness?
	tallness?	shortness?
	strength?	weakness?
	beauty?	ugliness?
	power?	powerlessness?
	contentment?	annoyance?
	love?	hate?
	good?	bad?

Have you found new things that are meaningful?

Any experience with nature can be expanded almost without limits. In your mind you can expand this small prairie into the extensive grassland area of which it is a part . . . then to the continent . . . and to the whole biosphere, the total world of life on this earth. There are no real boundaries--all these parts interrelate. And if you wish, you can expand it into this great natural universe in which we exist.

Or you can focus down to the area within your view, to your immediate surroundings, to one square foot of prairie, to one plant or even to one leaf as a world all its own, with many components living and functioning together.

The prairie can also be expanded in time back through the whole history of the earth, because the nature of the prairie at this instant in time has been conditioned by that entire history. And although our sensory interaction with the prairie is limited to the now, to brief time flashes, we can project it in the mind into the future as season will follow season.

How will you respond to this experience in the prairie? You may want to write a poem, make a sketch, make a design with natural colors from the prairie, or simply respond in thought.

Module 12: Supplement #2
Student Assignments (Elementary)

My Response to the Prairie

The following instructions should be given orally by the teacher to upper elementary students:

Today we want to use our senses to observe the details in a prairie and to make a feeling response to what we observe. You will not see something new, but I hope you will see something old in a new way. Write down in your notebook your answers to the questions on your assignment sheet and also your impressions and feelings.

This should be your own individual experience of the prairie. Therefore, do not disturb others. You should not talk to or shout at anyone else except me. You may walk around and look at different parts of the prairie, but let's not run around.

(Designate the area to be studied, the time and signal for quitting, and warn the students about poison ivy).

Now take the assignment sheet that you would like to work with and find a comfortable place to sit down and begin your observations. You may work with this assignment sheet for the whole time or you may come back and get a new assignment sheet if you are through with the first one.

(For younger elementary students, you will not use the above instructions, but will adapt some of the following questions to focus observations of the prairie made by the class).

Assignment Sheet 1

Look toward the horizon on all sides of you and observe the prairie around you. What do you see? What do you feel as a result of this?

Now look at the small parts of the prairie next to you. Look at one plant or a part of one plant. What do you see? What do you feel as a result of this?

List the colors that you have seen.

Where do you find curves, ovals, straightness, circles, waves? Do you see other shapes.

Do you see movements? What kinds of motion do you see?

Assignment Sheet 2

Listen! How many sounds can you hear? Listen for the soft sounds as well as the loud sounds.

Are some of the sounds musical? Are some of them noisy? Describe some of the sounds.

Do these sounds convey any feelings to you? Describe those feelings.

Was the maker of the sound trying to send a message? What do you think it might be?

Assignment Sheet 3

Use your sense of touch. Feel the surfaces and edges of objects. How many different kinds of surfaces can you feel?

Are some surfaces rough? Are some surfaces smooth?

Do some surfaces feel pleasant? Do some surfaces feel unpleasant?

Smell some of the objects around you in the prairie. Smell the surface of the soil, the grass litter, some of the plants. You may want to crush pieces of leaves before smelling them.

Do you like some of the smells? Which ones? Do you dislike some of the smells? Which ones?

How does the touch and smell of the prairie make you feel?

Dwight Platt

Module 13: Subdividing space in an ecosystem promotes species diversity

Age level: High school (Procedure A)
Junior high and upper elementary (Procedure B)

Subject: Biology

Theme: Diversity

Sequence: Field trip

Prerequisites: Modules 1, 6 and 11; Module 2 is recommended; Modules 3 and 4 are necessary if insects are to be identified

Objectives: To investigate the subdivision of space among different species of animals by stratification and zonation of a prairie ecosystem and to see how this contributes to species diversity in the community

Best season: May to October; best in late summer or early autumn and when surface soil and litter are moist

Time required: At least 1 hour at Sand Prairie Reservation; either the teacher, or the teacher and some students, will need to spend another hour two days before the field trip installing traps; additional time will be spent in the classroom following the field trip identifying animals collected and discussing the results

Materials required:
12 quart jars or juice cans (for pitfall traps)
Trowel
Covers for traps (available on loan from SKEEC)
Insect sweeping nets (available on loan from SKEEC)
Insect killing jar (available on loan from SKEEC)
Small plastic bags
Thermometer
Insect key (available on loan from SKEEC)
Tullgren funnels (available on loan from SKEEC)

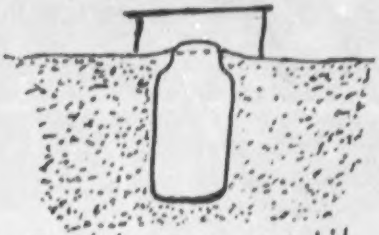
Investigation

Design of the investigation. The animals living in two or three strata of each of two vegetation zones of a prairie will be collected. Sampling of the animals living on the vegetation will be done with an insect sweeping net. Sampling of animals living on the surface of the ground will be by pitfall traps. If time is available, sampling of animals living in the litter and surface soil will be done with a Tullgren funnel.

Procedure A (for high school and advanced junior high students):

1. **Collection of data.** After the module describing some of the vegetation zones on Sand Prairie Reservation (Module 11), ask the class to decide which two vegetation zones they wish to sample. The zones that are best for sampling are: dunetops and upper slopes, tall lowland grass, willow

thickets, and pond or marsh edges. You, or you and several students from the class, should visit Sand Prairie Reservation two days before the field trip. Select a sample area of each of the two vegetation zones for study. SKEEC can supply you with a vegetation map that will show where these vegetation zones are located. In each zone, construct 6 pitfall traps, scattered within the sample area, by burying 6 of the glass jars or cans with the upper lip flush with the surface of the ground. The surface should be sloped up slightly around the trap so that rain will not drain into it. A cover can be set over the top to keep rain out. Thin legs support each corner of the cover and it should be kept high enough so there is no obstruction that would prevent small animals from falling over the edge into the trap.



Buried Trap and Lid.

Two days later take the class on a field trip to Sand Prairie Reservation. Ask the class to make the following observations and collect the following data in each of the zonal communities (each student should record information in a notebook):

a. Examine the 6 pitfall traps and make a list of the species of animals that have been trapped. For each species, list the number of individuals in the 6 traps. Identify the vertebrates by using the lists of vertebrates and field guides (Supplement #1). For insects and other invertebrates that cannot be readily identified, determine the number of species that have been trapped by noting differences in coloration, structure, or size. Give each species a letter (i.e. species A, species B, etc.) and, in the record of data after each species, record the number of individuals in the traps. For each unidentified species, kill one individual in the insect killing jar, wrap it in a sheet of paper, label it with the letter used in the data record and place it in a plastic bag. Label the plastic bag to indicate that the specimens were taken from pitfall traps and from the zone being sampled. All other animals should be released.

b. With a sweeping net, make 15 arm-length sweeps through the vegetation and quickly fold the net over the hoop so that any animals in the net cannot escape. Carefully dump the contents of the net into an insect killing jar. When the animals are dead, place them in a plastic bag. Label the plastic bag so that you can tell that these specimens came from a sweeping net and from the zone being sampled.

c. (optional). Collect a sample of surface litter and surface soil and fill a plastic bag. Label the bag. You will collect animals from this sample using a Tullgren funnel in the classroom.

d. Record temperatures in the vegetation where the insect sweeps were made, on the surface of the ground, and under the litter in the surface soil. Do not let the sun shine directly on the bulb of the thermometer while you are taking temperatures. All temperature readings should be made as near the same time as possible.

You will want to assign different groups of students to collect different data. Be sure each group understands what it is to do, what data it is to record, and what collections it is to make. At the end of the field trip, see that all of the following have been recorded or collected:

a. For each of two vegetation zones, a list of species and numbers collected in the pitfall traps and a collection of one specimen of each of the species that have not been identified.

b. For each of two vegetation zones, a collection of specimens taken in 15 sweeps of the net through vegetation.

c (optional). For each of two vegetation zones, a plastic bag full of litter and surface soil.

d. For each of the two vegetation zones, a record of temperatures in the vegetation, on the ground surface, and below litter in the surface soil.

If the optional study of soil and litter animals is to be done, two Tullgren funnels must be set up in the classroom after returning from the field trip, and the samples of litter and soil placed in them for a few days to collect animals living in this stratum (see Supplement #2).

If a display is to be made, the insects collected should be pinned as soon as you return to the classroom. (For techniques of pinning, see Gates and Peters, 1962; Knudsen, 1966; or the pamphlet by the staff of the Ward's Natural Science Establishment).

2. Identification of specimens. The specimens should be examined as soon as possible after they have been collected. If the collection cannot be analyzed immediately, the specimens should be sorted out from other debris collected and laid aside to dry in a position that makes it possible to examine all external parts most easily.

The investigation can be done without identifying the specimens. Students can examine the collection, separate the specimens into species by looking for differences and similarities and then give their own names to each species. You will need to help students by showing them what differences to look for to distinguish species and by helping them recognize some differences as only sex or age differences. Care should be taken to compare samples so that one species which is represented in two different samples is given the same name in both.

However, it is better, if time is available, to identify the specimens. Vertebrates can probably be identified to species with the references listed. Identification of insects and spiders can be done to order and family with the key available from SKEEC, and other invertebrates can be identified to phylum or class. The species of invertebrates can be recognized and given names or numbers by the students as suggested above. Assign groups of students to examine each collection and prepare a species list for that stratum. The species list for each stratum and zone and the numbers collected of each species should be tabulated on the chalkboard.

If identifications have been made, determine the food relationships of the animals from the reference books or the SKEEC insect key. This information can be saved for use in Module 35.

3. Interpretation and discussion. Compare each of the strata studied in one zone to see how different the animal life in these strata are. Ask students to calculate a similarity index to compare layers using the formula, $S.I. = \frac{2C}{A + B}$ where C is the number of species found in both strata, A is the number of species in one stratum, and B is the number of species in the other stratum. For invertebrates, identification of individual species will not have been made, but the students will have to judge whether specimens in two samples are of the same species or not. The larger the value of S.I., the more similar the two strata are.

   How different were the temperatures in each of the strata? Do you think other climatic features would differ in these strata? Discuss possible patterns that might be present in the variation of other climatic features.

   Compare the comparable strata in each of the two zones studied utilizing the methods suggested above. How does zonation contribute to the efficiency of the community and to the species diversity within the community?

   Discuss some of the following questions:

   a. Do you have any species that were found in all samples?

   b. Were most species found in only one sample? or more than one sample?

   c. Which are most similar in animal life--different strata within a zone or in different zones?

   d. Which species had the most individuals in each sample, those restricted to one sample or those found in a number of samples?

   e. If you would eliminate one stratum in both zones, how would it reduce the number of species or the species diversity collected in your samples?

   f. If you eliminate one zone, how would it reduce the number of species or the species diversity collected in your samples?

g. What are the food relationships of these animals? Diagram a food web for each zone.

h. Man often simplifies ecosystems. Can you give examples of man simplifying an ecosystem by eliminating a stratum? (Keeping grass very short by mowing or close grazing of a grassland). Can you give examples of man simplifying an ecosystem by eliminating zonation? (Planting a field, including both lowlands and uplands, to one crop plant).

You may want to ask each student to write a short report summarizing the data collected and answering some of these questions, or you may want to handle the interpretation as a class discussion.

A display can be made showing the animals found in each stratum of each zone. The insects collected can be pinned to a piece of poster board. Drawings can be made of the other animals that were collected, and some information on each animal can be written on the poster board.

Procedure B (for junior high and upper elementary students):

Collections are made as in Procedure A, except that you will need to help the students identify any vertebrates that are caught in pitfall traps; the rest of the animals caught do not need to be separated out by species in the field.

Assign groups of students to sort the collections from each stratum in each zone sampled. This should be done as soon as the collections are brought in from the field, or as soon as possible. Ask the students to examine the similarities and differences in the animals they have collected and to sort them out into what they consider to be different species. You will need to help students by showing them what differences to look for and by helping them recognize some differences as only sex or age differences. Each group should arrange their specimens on a table, putting all specimens in one species together in a pile.

Have each group consult with the group that sorted specimens collected in the comparable stratum in the other zone. Have them determine how many of the species in the two collections are the same and how many are different.

Now have each group consult with the group that sorted specimens collected in the other stratum in the same zone. Have them determine how many of the species in the two collections are the same and how many are different.

Each group should report on the collection they have sorted:

1. How many total species were in the collection?

2. How many species were similar to those collected in the comparable stratum in the other zone and how many were different? How many were similar to those collected in the other stratum in the same zone and how many were different?

3. How many species were in their collection that were in neither of the other collections that they examined?

Write the data on the chalkboard as it is reported.

Discuss the results using some of the following questions:

1. Did you expect to collect as many species as you did?

2. The collection from which stratum had the most species?

3. The collection from which zone had the most species?

4. Which were most similar in animal life--different strata within a zone or comparable strata in different zones?

5. If one stratum or one zone were eliminated, how would it reduce the number of species collected?

6. Man often simplifies ecosystems. Can you give examples of man simplifying an ecosystem by eliminating a stratum? (Keeping grass very short by mowing, or close grazing of a grassland). Can you give examples of man simplifying an ecosystem by eliminating zonation? (Planting a field, including both lowlands and uplands, to one crop plant).

Statement of Concepts

The species diversity of a natural community is the result of the availability of ecological niches to many different species. An ecological niche is the functional role of a species in a community and includes where it lives, physical conditions like temperature, moisture, light, etc., that it requires, its food sources, and its relations to animals that feed on it. Without an available ecological niche that satisfies its needs, a species cannot exist in a community. The spatial or habitat niche of an animal species is the space within the community where these animals live. The space in a community can be divided vertically into layers. This is called stratification. In a grassland these strata are: the air above the vegetation; the vegetation, which may be divisible into two or more vegetation strata in a tall grassland; the ground surface; the litter; and the soil. Each of these strata will have different daily cycles of temperature, humidity, light, wind, etc. So each has its own microclimate to which the animals living there are adapted. Many animals are restricted in their activities to one or a few strata. Here the animals must be able to satisfy all of the requirements for survival.

Most large communities don't exist on homogeneous sites. There are low areas and high areas, south slopes and north slopes, and sometimes differences in soil types. This variation provides a horizontal pattern of microhabitats, each with its own microclimate. Often different plants grow in different zones, providing different food for animals. This horizontal pattern of variation is called zonation. Many animals are restricted in their activities to one or a few zones.

Subdivision of the space of a community by stratification and zonation provides many different microhabitats in which different animal species can live. This is necessary for a high degree of species diversity.

Animals in a zonal community must not only find a suitable microhabitat, but must also find food. Diagrams of what eats what in a zone usually forms a food web.

References

1. Costello, David F. 1969. The Prairie World. New York: Thomas Y. Crowell, pp. 124-143, 151-159.
2. Gates, Dell E. and Leroy L. Peters. 1962. Insects in Kansas (2nd edition). Manhattan: Kansas State University Extension Service. (Techniques of pinning insects)
3. Knudsen, Jens W. 1966. Biological Techniques. New York: Harper and Row. (Techniques of pinning insects)
4. Smith, Robert L. 1974. Ecology and Field Biology. New York: Harper and Row, pp. 247-251, 552-555.
5. Staff of Ward's Natural Science Establishment. 1967. How to Make an Insect Collection. Rochester, New York: Ward's Natural Science Establishment. (Techniques of pinning insects)
6. Watt, Kenneth. 1972. Man's efficient rush toward deadly dullness. Natural History, vol. 81, no. 2, pp. 74-77, 80, 82.

Module 13: Supplement #1

Animal List

I. Vertebrates

A. Amphibia

1. Barred Tiger Salamander Ambystoma tigrinum mavortium
2. Plains Spadefoot Toad Scaphiopus bombifrons
3. Great Plains Toad Bufo cognatus (most common toad)
4. Rocky Mountain Toad Bufo woodhousei woodhousei
5. Plains Leopard Frog Rana pipiens

Along borders of ponds and marshes, small Bullfrogs, Blanchard's Crocket Frogs or Western Chorus Frogs may get into pitfall traps.

B. Reptilia

1. Eastern Ornate Box Turtle Terrapene ornata ornata
2. Lesser Earless Lizard Holbrookia maculata
3. Northern Prairie Lizard (Eastern Fence Lizard) Sceloporus undulatus garmani
4. Prairie Lined Racerunner (Six-lined Racerunner) Cnemidophorus sexlineatus viridis

References for identification:

a. Collins, Joseph T. 1974. Amphibians and Reptiles in Kansas. University of Kansas Publications, Museum of Natural History, Public Education Series No. 1.

b. Karns, Daryl, Ray E. Ashton, Jr. and Tom Swearingen. 1974. Illustrated Guide to Amphibians and Reptiles in Kansas: An Identification Manual. University of Kansas Publications, Museum of Natural History, Public Education Series No. 2.

c. Conant, Roger. 1975. A Field Guide to Reptiles and Amphibians of Eastern and Central North America (2nd edition). Boston: Houghton Mifflin Co.

C. Mammalia

1. Short-tailed Shrew (Shorttail Shrew) Blarina brevicauda
2. Little Short-tailed Shrew (Least Shrew) Cryptotis parva
3. Plains Pocket Mouse Perognathus flavescens
4. Western Harvest Mouse Reithrodontomys megalotis
5. Woods Mouse (White-footed Mouse) Peromyscus leucopus
6. Prairie Vole Microtus ochrogaster

References for identification:

a. Hall, E. Raymond. 1955. Handbook of Mammals of Kansas. University of Kansas Museum of Natural History Miscellaneous Publication No. 7.

b. Burt, William H. and Richard P. Grossenheider. 1952. A Field Guide to the Mammals. Boston: Houghton Mifflin Co.

II. Invertebrates

The most common animals in the samples will be insects and spiders. These are difficult to identify to species but they can be identified to order or family with the use of the key available from SKEEC. Other invertebrates can be identified to phylum or class.

Module 13: Supplement #2

A Tullgren funnel is used to extract animals from a soil sample by heating and gradually drying out the sample. You will need to set up two funnels, one for each of the two samples of litter and soil you have collected. The samples should be placed in cheesecloth on the hardware cloth shelf in the funnel. Place two small jars that contain a couple inches of 70% alcohol under the lower openings of the two funnels.

Place the light fixture with a 40- or 60-watt bulb over the top of the funnel. Leave the light on to heat and dry the sample for a few days. As the sample dries out, animals will crawl out of the bottom and fall down the funnel into the jar of alcohol. After the sample is dry, the animals that have collected in the two jars can be examined and identified.

Dwight Platt

Module 14: Circadian or diurnal rhythms

Age level: Upper elementary; small groups, no more than 5 to 6 per leader

Subject: Biology **Theme:** Rhythms

Sequence: Field trip **Prerequisite:** Module 7

Objectives: To investigate evidences of circadian rhythms in some animals and plants of a prairie community and the significance of some of these rhythms to the functioning of the community; to develop an understanding of observation and hypothesis formation

Best season: May 1 to November 1; temperatures during the evening field trip should be 65° F. or above, and for the daytime trip it should be sunny with no to light moderate winds

Time required: An evening field trip of 1 hour and a daytime field trip of 1 hour on Sand Prairie Natural History Reservation

Materials required:

One flashlight for each child
Stakes with numbered flags (available on loan from SKEEC)

Investigation

Part I. You can use Billington (1971) to introduce some general ecological concepts before the field trip, if needed. The evening field trip to Sand Prairie Reservation should be taken first, preferably in early evening. Each student should take a notebook to the field, in which to record observations. Discuss with the class the importance of making accurate and complete records. You may want to suggest that the observations made on the two field trips will be compared and suggest ways of recording that will make comparison easier.

1. Take the students to a location on Sand Prairie Reservation that is near to a number of different habitats. Point out the area in which they are to work (you should have checked out the area ahead of time to see that there is no poison ivy). Ask them to listen for 3 to 5 minutes and record in their notebooks whatever they hear. If they are not able to identify the sound, they should describe it.

2. Show the students a pepperwort fern Marsilea mucronata found along wetland edges or in lowland grass (looks like a "four-leafed clover;" SKEEC personnel can point it out for you). Point out the folded leaves as an example of the "sleep" position of leaves. Have the students describe or sketch the position of the leaves. Place a numbered flag near this plant. Each student should record the number on this flag in his/her notebook for future reference.

3. Give each student a dozen numbered flags. Now allow the students to explore on their own (if 2 students want to work together, allow it, especially if there is any indication that they are frightened). Tell

them to explore any habitats in the designated area but to stay within sight of your light and to return on a signal from you. They should record the following observations:

a. Look for other plants with apparently folded leaves. A numbered flag should be placed beside the plant, and the position of the leaves described or sketched.

b. Examine a number of blooming plants to see if the flowers are open or folded. Place a numbered stake beside an example of each kind of plant examined and record whether the flower was open or closed.

c. Look for active animals. They may try to find those that were making the sounds they recorded. They should record a description of the animals observed and the type of activity. Ask them to record common animals, not those seen only once or twice.

d. Search along the leaves, stems and flowers of a few plants and record descriptions of inactive or active animals that are commonly found.

Part II. The daytime field trip should be taken within a few days of the evening field trip. It is better in the middle part of the day during cool weather but in early morning or late afternoon when the weather is hot. The students should be taken to the site of the evening field trip on Sand Prairie Reservation.

1. Ask them to listen for 3 to 5 minutes and record what they hear.

2. Return to the pepperwort plant that was observed on the evening field trip. Are the leaves in a different position? Have the students describe or sketch the position of the leaves.

3. Allow the students to explore on their own.

   a. They should go back to the numbered flags, observe the plants, and describe or sketch the position of the leaves or record whether the flowers are open or closed.

   b. They should look for active animals and record a description of commonly observed animals and what they are doing.

   c. They should search along the leaves, stems, and flowers of a few plants and record descriptions of inactive or active animals that are commonly found.

   d. They should pick up all numbered flags and give them back to you.

4. Gather together for a short discussion in the field after they have made their observations. Compare the lists of sounds, plants, and animals made on the two field trips. Which things are similar; which are different? Some of the following questions can be discussed:

a. How many of the plants observed had different leaf positions at the two times?

b. Do some plants bloom during the day and some at night?

c. Why is the time of blooming important to the plant?

d. How many animals were seen both times and how many were seen only one time?

e. For those that were seen both times, was there any difference in their activity?

f. Where do you suppose the animals seen on only one field trip were when you made the other field trip?

g. How does this rhythmic activity allow more animals to live in a community? (If they are not familiar with the concept of a natural community, briefly introduce it).

h. Can you suggest ways in which the animals were adapted for activity during the times they were most active?

5. If you were to go back to the reservation in the evening and again make observations, would they be more similar to those made on the evening field trip or the day field trip? Why? Are these rhythmic activities of animals and plants related to rhythmic changes in the environment? What environmental rhythms seem most obvious? Are the rhythmic activities of plants and animals caused by these environmental rhythms?

Point out to the students that any answer to this last questions is an hypothesis that they are making from their observations. An hypothesis is not a proven explanation of their observations but an early step in finding such an explanation. If they have not suggested them, point out alternative explanations or hypotheses, such as:

a. The rhythmic activities of plants and animals observed are caused by or are direct responses to the rhythmic changes in light and darkness (or temperature or other factors).

b. The rhythmic activities of plants and animals observed are caused by rhythms within the plants or animals that are independent of the changes in light and darkness and are simply timed to correspond with the light changes (internal rhythms could be illustrated to the students by the periodic recurrence of hunger or fatigue in their experience).

Statement of Concepts

Animals and plants in a community usually have rhythms of activity that repeat in 24-hour cycles. Such 24-hour rhythms are called circadian or diurnal rhythms. These rhythms may not be the same for all animals and plants in the community. Therefore at different times of the day there are different animals that are active. Plants, of course, need sunlight to carry on photosynthesis and make their food. Therefore, at night no plants are actively carrying on photosynthesis. Some of them may allow their leaves to droop in "sleep movements" and these movements may reduce loss of water.

Animals can be active at any time of the day but are usually best adapted for hunting food and escaping enemies at particular times when light levels, temperatures, and humidities are nearest the optimum. From day to night the active animals in the community may be entirely different. In this way two different "communities" can share the same area. This adds to the diversity of the community.

Flowers open when the animals they depend upon as pollinating agents are active. Some flowers open only once, at a time when the pollinating animals are active. Other flowers open and close a number of times during a 24-hour cycle so that their nectar and scents are made available at a time when they will attract pollinators.

Some biological rhythms are simple responses to rhythms in the physical environment and only occur in the presence of those rhythms. The leaves of a plant may droop in the dark but may remain upright as long as it is light. Other rhythms are intrinsic or endogenous and, although they may be timed to coincide with rhythms in the environment, are maintained in the absence of such rhythms. Some plants may continue rhythmic leaf movements even in continuous light or dark.

References

For the teacher:

1. Allen, Durward L. 1967. Creatures of the Grass. The Life of Prairies and Plains. New York: McGraw-Hill, pp. 59-125.

2. Brown, Frank A., J. Woodland Hastings and John D. Palmer. 1970. The Biological Clock--Two Views. New York: Academic Press, pp. 3-12.

3. Palmer, John D. 1971. The rhythm of the flowers. Natural History, vol. 80, no. 7, pp. 64-73 (August/September).

For students:

1. Billington, Elizabeth T. 1971. Understanding Ecology. New York: Frederick Warne & Co.

2. Lieser, Julia F. 1972. Fiddler in the night. Ranger Rick's Nature Magazine, vol. 6, no. 6, pp. 8-10 (July). Good reading if you found a katydid.

3. Ranger Rick's Nature Magazine, vol. 8, no. 5, pp. 41-43 (May/June, 1974) for ideas to follow up this study.

Dwight Platt

Module 15: A study of interdependence at a flower

Age level: Upper elementary; small groups, no more than 6 to 8 per leader

Subject: Biology **Theme:** Interdependence

Sequence: Field trip **Prerequisites:** Modules 5 and 4

Objective: To study the interrelationships of animals visiting a flowering plant and their dependent relations on the plant

Best season: The following plants can be used for this investigation; the average periods for maximum blooming are indicated (check with SKEEC to determine the best time in a particular year):

1. Chickasaw plum--April 1 - 20
2. Puccoon--May 1 - 31
3. Buckley's penstemon--May 1 - 15
4. Roughleaf dogwood--May 30 - June 10
5. Prickly poppy--June 7 - 30
6. Butterfly milkweed--June 7 - July 11
7. American elderberry--June 12 - July 20
8. Silky prairieclover--July 1 - 31
9. Fourpoint eveningprimrose--July 1 - August 25
10. Camphorweed--August 5 - September 24
11. Showy partridgepea--August 10 - September 15
12. November goldenrod--August 22 - October 10

Time required: 1 hour field trip on Sand Prairie Natural History Reservation

Materials required:

Slide set #8: "Insects that Visit Flowers" (available on loan from SKEEC)
Insect suction tube aspirators (available on loan from SKEEC)
Insect killing jar for each leader (available on loan from SKEEC)
Insect keys - one for each student (keys for insects visiting specific flowers are available on loan from SKEEC)

Investigation

1. You may want to read the article by Livaudais (1974) to your class before the field trip and have them observe some simple flowers to find the pistil, stamens, and petal. You may also want to read the article by Fischer (1967) to your students before the field trip.

2. Show the slide set, "Insects that Visit Flowers," in order to acquaint the students with some of the insects that they will observe on the field trip.

3. When you arrive at Sand Prairie Reservation on the field trip, divide the class into small groups of 6 to 8 students with a leader for each group.

4. Show the students the flower that is to be studied. Discuss the parts of the flower and which parts are essential for reproduction and which are to attract pollinators. (Some of the flowers that you may use are specialized or complicated and, if necessary, you can consult with SKEEC personnel beforehand to interpret them). Discuss ways in which animals might be dependent on this plant and the plant might be dependent upon animal visitors.

5. Give each student a copy of the insect key that you have borrowed from SKEEC. Now ask each student to find an observation site where he/she can observe one or more of the plants with flowers. He/she should record in a notebook a description of each animal that is found on the plant or that visits the plant. He/she should particularly observe the flower. The following observations should be made and recorded:

    a. Where is the animal found on the plant?

    b. Identify the kind of animal, using the key that is furnished. If it cannot be readily identified, it should be caught with the aspirator so that it can be observed in the vial. If the student cannot identify it, he/she should take it to the leader who will either help identify it or will kill it to take back to the classroom for further observation. The students should be encouraged to call their leader to help with large insects that they cannot identify with the key. The student may want to record information on color pattern or other characteristics so that he/she can identify it more specifically later. Students should realize that they will probably not be able to identify all of the insects that visit the flower. Some may be too small to see easily, some may leave too quickly, and some may not have been included in the key. They should work carefully to get accurate identification on those that they can so that they have an accurate list, if not a complete list.

    c. How is the animal dependent on the plant? Check the information at the end of the key, if the insect has been identified. Observations of the way in which the insect satisfies a need in relation to the plant should be recorded. If it collects nectar or pollen, they should describe the way in which this is done.

    d. In what ways is the structure or color of the animal adapted for its way of life and its relation to the plant?

6. Leaders should visit each student-observer and help to focus his/her observations by asking questions.

7. The students may be asked to observe a second kind of flowering plant at the end of the field trip to see whether it is visited by the same or different animals.

8. When they return to the classroom, the students should complete any identifications that are unfinished. If they cannot identify some of the specimens that were collected, they may want to send them to SKEEC to see if personnel there can identify them. They will want

to share their observations and discuss the different animals observed and their interrelationships. While members of the class are describing their observations, draw a diagram on the blackboard that shows these interrelationships and add information from the characterizations in the key (see accompanying example in Supplement #1).

9. Discuss what might happen if some of the animals or the plant in this diagram were removed. What effects would it have on the other organisms?

Statement of Concepts

Animals and plants in a natural ecosystem are interdependent. Some of the most basic interdependencies are those involving food. An animal feeds upon another organism in order to obtain matter and energy for survival and, in turn, it passes matter and energy on to other living organisms when it is eaten or dies and decomposes. These relationships which link organisms together are known as food chains.

The plant is the first link in a food chain, for it can use the energy of sunlight in the manufacture of food. In the flower, rich food in the form of nectar and pollen is provided as an attraction to insects or other small animals to carry pollen from flower to flower to make reproduction of the plant possible. The plant is dependent on its pollinators in order to reproduce, and the pollinators are dependent on the plant for food. Other animals may feed on the tissues of the leaves or suck the plant juices.

The plant may also be directly important to predatory animals that feed on other animals. A predatory spider or insect may hide in the flower to catch another insect coming for nectar or pollen. Some of these predators are adaptively colored so they are not easy to see. Other predators may search the leaves and stems of the plant to capture plant feeders found there.

Many of these interdependencies are obligatory so that an animal or plant cannot survive or cannot reproduce without certain other animals or plants that are necessary to satisfy its needs.

References

For the teacher:

1. Costello, David F. 1969. The Prairie World. New York: Thomas Y. Crowell, pp. 136-141.

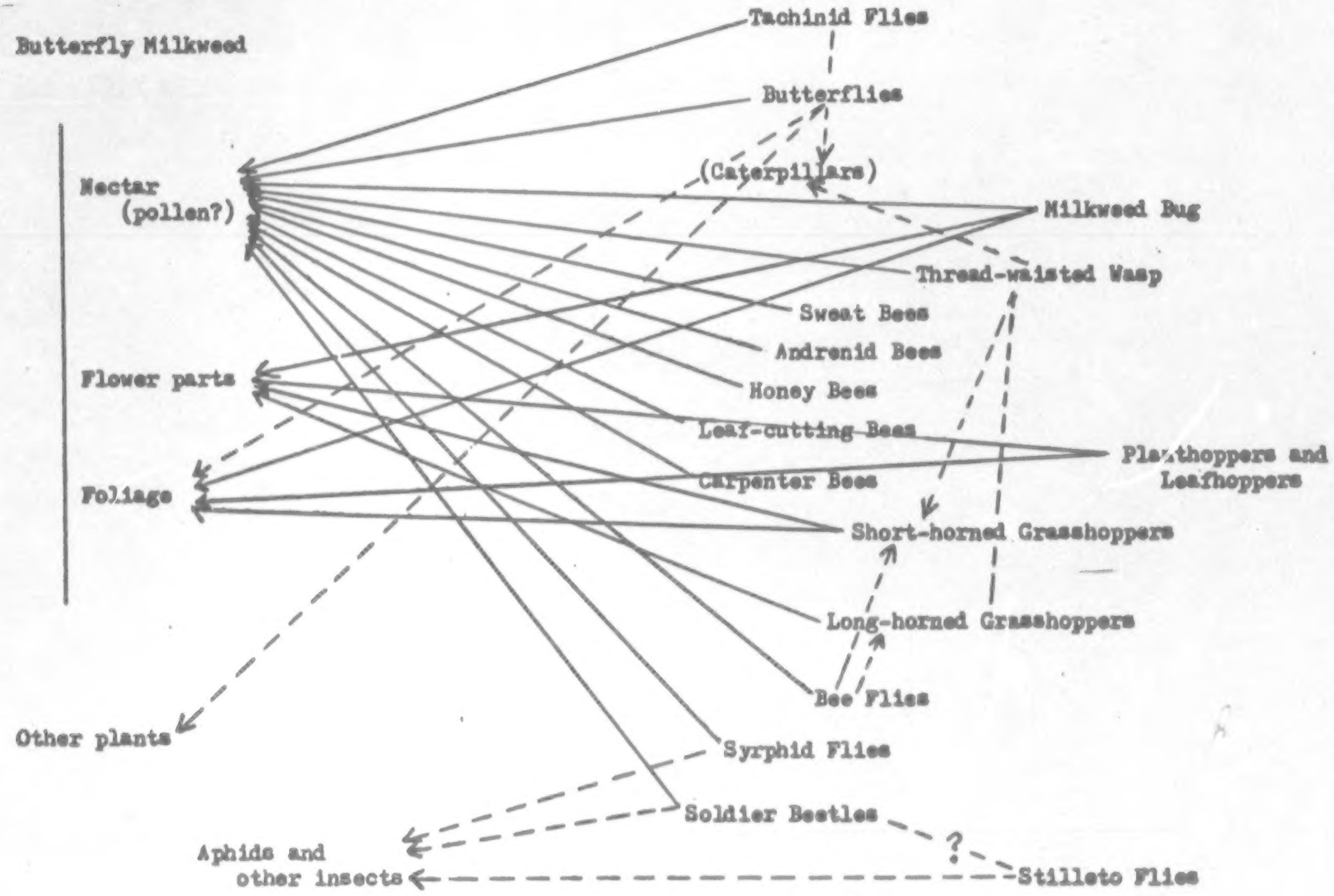
For students:

1. Anonymous. 1971. Who-dun-it. Ranger Rick's Nature Magazine, vol. 5, no. 7, p. 17 (August/September).

2. Fischer, Richard B. 1967. The goldenrod jungle. Ranger Rick's Nature Magazine, vol. 1, no. 7, pp. 30-32 (August).

3. Livaudais, Madeleine. 1974. In the heart of a flower. Ranger Rick's Nature Magazine, vol. 8, no. 7, pp. 39-40 (August/September).

Module 15: Supplement #1
Interdependencies at Butterfly Milkweed Flowers


Butterfly Milkweed
Nectar
(pollen?)
Flower parts
Foliage
Other plants
Tachinid Flies
Butterflies
(Caterpillars)
Milkweed Bug
Thread-waisted Wasp
Sweat Bees
Andrenid Bees
Honey Bees
Leaf-cutting Bees
Carpenter Bees
Planthoppers and
Leafhoppers
Short-horned Grasshoppers
Long-horned Grasshoppers
Bee Flies
Syrphid Flies
Soldier Beetles
?
Aphids and
other insects
Stilleto Flies

Dashed lines indicate relations of other life cycle stages.

Dwight Platt

Module 16: A study of the insect visitors to different kinds of flowers

Age level: High school

Subject: Biology   Theme: Interdependence

Sequence: Field trip   Prerequisites: Modules 6, 3 and 4

Objective: To study the specificity of the interdependent relationship between some flowering plants and their insect visitors

Best season: May 1 to October 1

Time required: A field trip of at least 1½ hours on Sand Prairie Reservation (if optional investigations are done, other field trips will be required); at least 2 hours in the classroom

Materials required:

Slide set #8: "Insects that Visit Flowers" (available on loan from SKEEC)
Insect suction tube aspirators - one for each group of students (available on loan from SKEEC)
Insect nets - one for each group of students (a few available on loan from SKEEC)
Insect killing jars - one for each group of students (a few available on loan from SKEEC)
Insect and spider keys (available on loan from SKEEC)
Small boxes, cans, plastic bags, or envelopes to hold insect collections in the field (enough for each group of students to have one for each kind of flower studied)

Investigation

Part I. Preparation

1. Before the field trip, the question of the specificity of insect-flower relationships should be raised. Does a specific kind of insect visit any flower that is blooming or does it visit only particular kinds of flowers? Planning should be done for a field trip investigation to try to answer this question. You can modify the following suggested procedure if it seems desirable.

2. In addition to the topics introduced in the prerequisite modules, the students should be familiar with the structure of a simple flower and the structure of the flowers they will be observing on the field trip. In choosing flowers to use in this investigation, you can consult SKEEC personnel for advice on the best flowers to use and on the structure of those flowers.

3. You can use the slide set, "Insects that Visit Flowers," to familiarise students with some of the kinds of insects that they will find on the field trip.

Part II. Field trip

1. Each student should take a notebook on the field trip for recording data. After arriving at Sand Prairie Reservation, the class should be divided into groups of 2 to 4 students each, who will do the investigation together. Be sure that everyone can recognize the first flowering plant to be studied. The class should agree on the following procedure. Each group will examine some of the plants to be studied and collect one specimen only of each kind of animal found on or visiting the plant. (Be sure everyone knows how to use the aspirator and the insect killing jar). Each specimen collected should be given a designation (species A, species B, etc.) and a brief description recorded in a notebook so that it can be recognized after it is taken out of the killing jar. Also observations about this specimen or others like it should be recorded:

    a. Approximately how many of this kind of insect were observed on the plant during the observation period?

    b. Where on the plant was it found?

    c. What was it doing?

    After taking a specimen out of the killing jar (emphasize that it should be left in the killing jar for 5 minutes after it quits moving to be sure it is dead), it should be wrapped carefully in a small piece of paper with legs and wings folded normally; the paper should be labeled with the designation of the specimen (A, B, C, etc.) and placed in one of the containers that is labeled with the name of the flower being investigated.

    Agree on a signal to end the observation period and let them begin the investigation.

2. After 15 to 20 minutes, call the class back together. Give them time to complete the wrapping and labeling of the specimens they have been collecting. Ask if there are any questions or problems.

3. Now they should follow the same procedure with the second kind of flower. You should give them the same length of time for observing it. You can do a third kind of flower, if you wish.

Part III. Analysis and interpretation

1. If a display is to be made (as described later), each group of students should carefully pin their insects as soon as they get back to the classroom. Directions for pinning insects can be found in Gates and Peters (1962), Knudsen (1966), or in the pamphlet prepared by the staff of Ward's Natural Science Establishment (see References). If no display is to be made, the collections do not have to be handled immediately, but should be handled as soon as convenient.

2. All specimens should then be identified as specifically as possible. Identifications to family can be made with the insect and spider keys available from SKEEC. Some specimens, particularly butterflies, may be identified to species by using Dell and Gates (1962) and Klots (1951).

   Also each group should find out as much as they can about the ecological characteristics of the species they observed and see if this information agrees with the observations they made.

3. Displays can be made to show the different kinds of animals that were observed to visit each of the kinds of plants. These displays can be class displays, pooling the information and observations from all of the groups, or each group can make its own display. If displays are to be made, sprigs of the plants being studied should have been collected and pressed. A dried flower can be glued to a piece of poster board and then the animals that were found visiting that flower can be pinned around it. Some information about the relation between the animal and the plant can be written on the poster board.

4. Each group should give a brief report of the results of their investigation to the class. The results of the investigation should be discussed. Some of the following questions may be used as a basis for discussion:

   a. How many species of animals were found on only one kind of flower? How many were found on more than one kind of flower? Each group should summarize their data and then the data from the whole class might be pooled.

   b. Were those species found on more than one kind of plant equally common on each plant?

   c. Did you obtain evidence that some species of animals and plants have very specific relationships?

   d. What are some of the differences in the flowers by which an insect could distinguish between them? Do you think there might be some differences which you cannot even sense? (You might point out that some insect eyes are sensitive to ultraviolet as a color which our eyes cannot detect).

   e. How do flowers that depend upon insect pollinators differ from those that have wind-carried pollen? Why? You can have the class look at a grass flower and compare it to the flowers that they investigated.

   f. What would happen if one of these species, either plant or animal, were eliminated from this prairie community? Would other species be affected? Which ones?

5. Read to the class, or assign for reading, the article by Becker (1965) and discuss it.

6. Point out to the class that the interrelationships studied are some of the many interdependencies that are necessary for the continued functioning and survival of a prairie as a diverse and complex ecosystem.

7 (optional). This study suggests other questions that could be investigated:

a. Do the same insects visit a flower during the whole period of the day that it is blooming? (A similar investigation could be done by making collections from the same kind of flower at the beginning of its blooming period and toward the end of its blooming period on one day).

b. Do the same insects visit a flower throughout its blooming season? (If one of the kinds of plants will be blooming for a while longer, a second collection could be made from that flower at the same time of day in similar weather conditions a week or 10 days later and compared to the first collection).

c. Do insects visit different flowers after a particular kind of flower stops blooming, or is their activity period limited to the season when that flower blooms? (Two or three kinds of insects that were found only on one flower can be selected for further study. Later, when this flower is no longer blooming, a second field trip could be taken. The students could examine all the flowers they now find blooming on the Sand Prairie Reservation to see if they can find any of the kinds of insects that were selected for study visiting other flowers).

Statement of Concepts

Insects and flowering plants have evolved an intricate interrelationship that is necessary for their survival. In the flower, rich food in the form of nectar and pollen is provided as an attraction to insects or other small animals to carry pollen from flower to flower to make fertilization and reproduction of the plant possible. The plant is dependent on its pollinators in order to reproduce and the pollinators are dependent on the plant for food.

Some insects may exploit the abundant food available in a flower but not be very efficient pollinators. Crawling insects, such as ants, or insects that eat petals or other parts of the flower may be of this type. In order for an insect to be an effective pollinator, it must visit a number of flowers of the same kind so it can carry pollen from one to another. This implies an ability to recognize a particular kind of flower. The colors, structural patterns and scents of flowers are advertisements to insects and insects may use them as clues for recognition (see Becker, 1965, p. 40). Some plants that grow in closely-spaced stands, such as grasses, may not depend upon insects as pollinators, but allow wind to carry the pollen. Their flowers usually do not have petals or nectar or scents to attract insects.

Some insects that are effective pollinators may visit many kinds of flowers to obtain food. But an individual on one trip collecting food or during a specific blooming season may limit its visits to one kind of flower.

Honeybees behave in this way. Some other insects may utilize only one or a very few kinds of flowers as a source of food, and their period of activity is primarily limited to the blooming season of those flowers. This then may become a very specific relationship between one kind of pollinator and one kind of flower. The structure of the flower and the structure of the insect may be adapted to one another to limit feeding by other animals and to make pollination more efficient.

The plant may also have important relations with other kinds of animals that visit it. Some animals feed on the tissues of leaves or stems, or suck the internal plant juices. Predatory animals may hide in the flower to catch an insect coming for nectar or pollen. Some of these predators are adaptively colored so that they are not easy to see. Other predators may search the leaves and stems of the plant to capture plant feeders found there.

Many of these interdependencies are obligatory so that an animal or plant cannot survive or cannot reproduce without certain other animals or plants that are necessary to satisfy its needs.

References

For identification and techniques:

1. Gates, Dell E. and Leroy L. Peters. 1962. Insects in Kansas (2nd edition). Manhattan: Kansas State University Extension Service. (Identification and techniques of pinning insects)

2. Harrington, H. D. and L W. Durrell. 1957. How to Identify Plants. Denver: Sage Books. (Techniques of pressing plants)

3. Klots, A. B. 1951. A Field Guide to the Butterflies. Boston: Houghton Mifflin. (Identification)

4. Knudsen, Jens W. 1966. Biological Techniques. New York: Harper and Row. (Techniques of pinning insects and pressing plants)

5. Staff of Wards Natural Science Establishment. 1967. How to Make an Insect Collection. Rochester, New York: Ward's Natural Science Establishment. (Techniques of pinning insects)

Student reading assignment:

1. Becker, Herman F. 1965. Flowers, insects, and evolution. Natural History, vol. 74, no. 2, pp. 38-45.

Dwight Platt

Module 17: Bird homes

Age level: Junior high; small groups of 6 to 8 students per leader

Subject: Biology **Theme:** Interdependence

Sequence: Field trip **Prerequisites:** Modules 6 and 4

Objectives: To investigate the dependence of birds on plants or other animals to satisfy their nest construction requirements; to encourage careful observation

Best season: After the nesting season in late summer or early autumn is best, although the investigation can be done up to early winter

Time required: A field trip of 1 hour on Sand Prairie Natural History Reservation and 1 hour to discuss the field trip in class

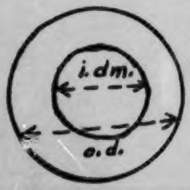
Materials required:
Rulers - one for each group of students
Hand lens - few
Bird nest key (Supplement #1) - make duplicates so there is one copy for each group of students
Binoculars (optional, but useful for the leader of each group)

Investigation

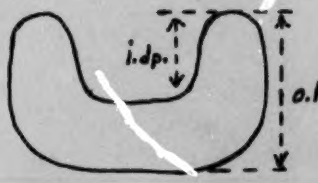
1. Before the field trip, make sure that:

   a. The students know how to use a dichotomous key (Module 4 can be used).

   b. The students know how to measure the dimensions of a bird nest:
   o.d. - outside diameter
   o.h. - outside height
   i.dm. - inside diameter
   i.dp. - inside depth
   Measurements should not be made to the tip of protruding sticks but to the main rim or bottom.



Nest - top view



Nest - side view

   c. Each leader can recognize the following plants (instruction in the recognition of these plants can be obtained from SKEEC personnel before the field trip, if necessary): black willow tree, mulberry tree, cottonwood tree, buttonbush, chickasaw plum bush, little bluestem grass, and switchgrass. Most nests will be found supported or sheltered by these plants. If nests are found in association with unknown plants, the students should give their own name to the plant and collect a small piece of it. Then they can identify it later. Leaders should also be able to identify poison ivy.

2. Birds that are known to nest on Sand Prairie Reservation (other than those always nesting over water or in holes in a tree) include:

a. Green Heron
b. Mallard
c. Blue-winged Teal
d. Bobwhite
e. Ring-necked Pheasant
f. Mourning Dove
g. Yellow-billed Cuckoo
h. Eastern Kingbird
i. Blue Jay
j. Catbird
k. Brown Thrasher
l. Blue-gray Gnatcatcher
m. Bell's Vireo
n. Yellowthroat
o. Eastern Meadowlark
p. Red-winged Blackbird
q. Orchard Oriole
r. Northern (Baltimore) Oriole
s. Common Grackle
t. Cardinal
u. Dickcissel
v. American Goldfinch
w. Lark Sparrow
x. Field Sparrow

The class should study some of these birds so that the students feel familiar with them. You should try to find pictures of many of them. The nests the students are most likely to find are: Mourning Dove, Yellow-billed Cuckoo, Eastern Kingbird, Brown Thrasher, Bell's Vireo, Red-winged Blackbird, Orchard Oriole, Northern (Baltimore) Oriole, Cardinal, and Field Sparrow.

3. Each student should take a notebook on the field trip to record observations. When you arrive at Sand Prairie Reservation, divide the class into small groups of 6 to 8 students and assign each group to a leader. Point out the plants listed above to the class and show the students how to recognize them.

4. Tell the students that 38 different kinds of birds have been known to nest on Sand Prairie Reservation. The key can be used to identify the builders of most of the nests that will be found. Many birds build nests in trees or shrubs, but some prairie birds build their nests on the ground or in grass clumps. Nests built on the ground or in grass clumps will be more difficult to find than nests in trees or bushes, but if students are observant they may find them.

5. Review the concept of interdependence briefly. Raise the question: Are birds dependent on other animals and on plants to be able to nest successfully? Point out that the objective of this field trip is to explore this dependence.

6. Each group of students is to look for bird nests. Encourage them to search carefully in the plants that have been pointed out to them as well as on the ground in thick grass to find nests. Some nests may be found high in trees. The students should be told not to climb to

observe these nests unless their leader gives permission. They will have to make some estimates about characteristics of these nests. A pair of binoculars will be helpful, if available.

7. The bird nest key should be used to identify the builders of each nest found. In some cases, they may only be able to determine that the nest was built by one of two or more species that build similar nests.

8. For each nest found they should record the following information (ask each student to record all of the observations of the group in his/her notebook):

   a. Size of nest and main materials of which it is composed
   b. Species of bird that probably built the nest
   c. Approximate height above the ground
   d. Plant or plants that provide support for the nest
   e. Plant or plants that provide shelter for the nest (usually the same as d, but sometimes different, especially for nests on the ground).

9. Students should not disturb the nests they find any more than necessary. Warn them to be particularly careful not to disturb a nest if there is evidence that an animal is still using it as a home. However, if SKEEC personnel have given permission, each group should collect one nest to take back to the classroom.

10. Back in the classroom each group will report their observations. Compile a composite list of all the nests found in a table on the chalkboard. The table might take the following form:

Plants Used for Support or Shelter of Nests

Species	No. of nests	Height of nests	Willow	Cottonwood	Buttonbush	Plum	Etc.
Eastern Kingbird							
Blue Jay							
Brown Thrasher							
Etc.							

Record the number of times each species of plant was used to support the nest of a particular species of bird or to shelter it. Also record the range in heights for the nests of each species.

11. The following questions can be used to start discussion on the patterns in the observations:

a. Do different species of birds appear to have different preferences for plants to support or shelter their nests?

b. Do you think the birds recognize and seek out certain species of trees or other plants in which to build nests? Or do they "prefer" certain species of plants because of the conditions or sites found in these plants (i.e., they grow in a suitable habitat, have suitable branches for support, have a preferred density of foliage, provide a preferred height of support, etc.)? (See Statement of Concepts).

c. Do different species of birds build their nests at different heights? Do they use any plant of that height to support or shelter the nest or are other characteristics of the plant important?

d. What would happen if plum bushes (or some other plant) were eliminated from Sand Prairie Reservation? Might some species of birds no longer nest on Sand Prairie Reservation or nest in smaller numbers? Which birds would be most affected?

e. In what ways do the plants that serve as nesting sites for these birds provide protection for the eggs and young birds?

12. Now ask each group to dissect the nest that they have brought back from the field trip. As the nest is taken apart each different kind of material should be placed in a separate pile. They should identify, so far as possible, the types of animal or plant from which the material came.

13. Have each group record on the chalkboard the kind of nest they dissected and a list of the different kinds of materials that it contained.

a. What birds have used the most different kinds of materials?

b. What kinds of materials were used most commonly in all of the bird nests dissected?

c. Did other animals produce any of the materials that were used in any of the nests?

Most birds are dependent on many plants and often some other animals in the construction of their nests.

Statement of Concepts

Birds are members of natural communities or ecosystems and depend upon other members of the community for materials and sites for nest construction. In picking a site for nest construction, most birds do not seek out one certain species of plant. However, each species of bird has specific requirements for its nest site. These requirements may include height, density of foliage, suitable branches for anchoring the nest, nearness to water, etc. Seeking out sites that best satisfy their requirements often results in a bird species utilizing only one or a few species of plants which it is dependent upon for nest sites. Although, if the plants that provide good nest habitat and nest sites for a particular species of bird are not present, it will sometimes nest in unusual places, but it will not nest there in any abundance.

The site chosen by a bird for its nest provides a degree of security against predators, either because of its relative inaccessibility or its inconspicuousness. (Of course, many nests become conspicuous after the nesting season when the leaves fall in the autumn). Birds may adapt to different conditions by seeking new types of secure nesting sites. For instance, in dry years most Orchard Orioles and Eastern Kingbirds build their nests in relatively high locations in willow trees on Sand Prairie Reservation. However, when many of the low buttonbush areas are flooded, most of the nests of these species are built in the flooded buttonbushes in lower locations but where the water provides some security from predators.

Each species of bird builds a nest of a specific size and pattern. Specific kinds of materials are used for the various layers of the nest. Some have very specific requirements for nest materials. The American Goldfinch almost always uses the down of a thistle, the Great Crested Flycatcher usually lines his nest with the castoff skin of a snake, and the Blue-gray Gnatcatcher lines the outside of its nest with spider silk. Birds will sometimes use materials that have similar properties to the usual materials. However, most birds have preferences for specific types of construction materials and must find them in the territory where they will nest.

These dependencies for shelter and nesting sites are often as important as the dependence on food in determining whether a species of bird can successfully live in a given area. When the Starling, an introduced bird from Europe, becomes common in an area it often causes a decline in the populations of some hole-nesting native birds because it takes over the suitable holes in trees for nesting.

References

1. Bent, Arthur Cleveland. Life Histories of North American Birds. (A multi-volume series republished by Dover Publishing Co.)

2. Harrison, Hal H. 1975. A Field Guide to Birds' Nests. Boston: Houghton Mifflin.

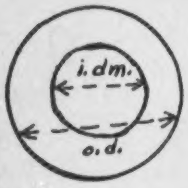
3. Headstrom, Richard. 1970. A Complete Field Guide to Nests in the United States. New York: Ives Washburn, Inc.

4. Welty, Joel Carl. 1962. The Life of Birds. Philadelphia: W. B. Saunders Co., chapter 14: Nests, pp. 252-281.

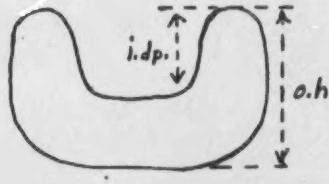
Module 17: Supplement #1

Key to Bird Nests Found on
Sand Prairie Natural History Reservation

Measurements of nests should be made in the following standard manner: the outside diameter (o.d.) is measured across the nest from one outside edge to the other; the inside diameter (i.dm.) is measured across the nest between the inside edges of the rim; the outside height (o.h.) is measured on the outside from the bottom of the nest to the top of the rim; the inside depth (i.dp.) is measured from the floor of the cup to the top of the rim.



Nest - top view



Nest - side view

Measurements should not be made to the tip of protruding sticks but to the main rim or bottom. Measurements given in the key are approximate, and measurements of nests in the field will not agree exactly.

After the nesting season, leaves and other debris may collect in the cup of the nest. Do not include these materials as construction materials used in the nest.

In using this key, first determine which section of the key to use:

- I. Nests found in trees, shrubs, or tall sedges more than 18 inches above the ground.
- II. Nests on ground or in grass clumps or rarely in low shrubs less than 18 inches above the ground.
- III. Nests in holes in a tree.
- IV. Nests floating on water in sedge marsh or among flooded shrubs.

- - -

I. Nests found in trees, shrubs, or tall sedges more than 18 inches above the ground.

- 1A. Outside of nest with some twigs, small sticks, or weed stems; nest situated upon a branch or in a crotch of a tree or shrub.
  - 2A. Outside diameter of nest greater than 9 inches.
    - 3A. A platform of sticks without lining; in shrubs or small trees 3 to 10 feet high, usually over water; outside diameter 10 to 12 inches--Green Heron.
    - 3B. A globular nest; often with small branches with leaves attached; situated more than 10 feet high in willows or other trees--(Fox Squirrel, not a bird nest).

2B. Outside diameter of nest 9 inches or less.

- 4A. A shallow platform nest, not cup-shaped.
  - 5A. A poorly constructed platform of a few twigs and small sticks; little or no inside lining; often breaks up within a short time after the nesting season--Mourning Dove.
  - 5B. Platform composed of twigs, small sticks, rootlets and strips of bark; some lining of grass, dry blossoms or catkins; usually sitting on top of a horizontal branch; outside diameter up to 7½ inches and outside height to 4 inches--Yellow-billed Cuckoo.
- 4B. Nest is cup-shaped with well-formed depression in center.
  - 6A. Outside of nest with some twigs but primarily with weed stems, leaves and some grass. (You may not always be able to distinguish between the following two nests).
    - 7A. Often containing cottony plant down, cloth or feathers; lined inside with fine grass, plant down, rootlets and/or hair--Eastern Kingbird.
    - 7B. Usually without plant down, cloth or feathers; lined with fine grass or hair--Cardinal.
  - 6B. Outside of nest primarily composed of twigs or small sticks.
    - 8A. Inside depth of nest 2½ inches or more; outside diameter 7 inches or more and inside diameter 3½ inches or more; in shrubs or in tall trees. (When the nests are located so high that they cannot be examined closely, the following two nests may not be distinguishable).
      - 9A. Inside diameter of nest 4 inches or more and inside depth 3½ inches; sometimes with a layer of dried mud in the nest; lined inside with fine grass and/or rootlets--Common Grackle.
      - 9B. Inside diameter of nest 3½ to 4 inches and inside depth 2½ inches; no dried mud in nest; of sticks, twigs, bark strips, leaves, dry grasses and often various odd materials; lined inside with fine rootlets and bark strips--Blue Jay.
    - 8B. Inside depth of nest 1½ inches or less; outside diameter of nest 6 inches or slightly more; inside diameter 3 3/4 inches or less; no dried mud in nest; usually in small trees or shrubs or less than 10 feet high in large tree. (The following two nests cannot always be distinguished).
      - 10A. Inside diameter of nest 3 inches or less and inside depth 1½ inches; outside height 3 inches; of sticks, twigs, grass, leaves, weed stems and bark strips lined with fine rootlets--Catbird.

10B. Inside diameter of nest 3 to 3 3/4 inches and inside depth 1 inch; outside height 3 3/4 inches; more bulky nest of sticks, twigs, leaves, bark strips and weed stalks lined with fine rootlets--Brown Thrasher.

1B. Nest containing no or few sticks or twigs; outside composed of grass, plant fibers, spider silk or other fine material.

11A. Nest at least partially suspended by the brim from the fork of a branch of a shrub or tree; deeply cup-shaped.

12A. Less than 2 inches inside diameter; compact smooth nest of plant fibers and leaves lined inside with fine grass, rootlets, hair and/or plant down; suspended from the branch of a low shrub--Bell's Vireo.

12B. More than 2 inches deep inside; in tall shrub or tree.

13A. Almost entirely of grass, usually appears somewhat yellowish; outside height 2½ to 3½ inches; cup-shaped--Orchard Oriole.

13B. Of plant fibers, grass, hair and bark strips; grayish brown; outside height 5 inches; fully-suspended, gourd shaped or bulging at the bottom--Northern (Baltimore) Oriole.

11B. Nest not suspended from brim but sitting on support or sides woven around support.

14A. Outside diameter 2 inches or less; usually saddled on top of branch of a tree or shrub but sometimes in a fork; compact and cup-shaped; of plant down, withered blossoms, fine grass and old leaf stems; outside coated with spider silk; lined inside with fine grass, fine strips of bark, tendrils, feathers and/or hair--Blue-gray Gnatcatcher.

14B. Outside diameter greater than 2 inches.

15A. Outside diameter 3 inches; in upright fork of a shrub or small tree; of fine grass, bark strips, and moss lined inside with thistledown--American Goldfinch.

15B. Outside diameter 5 inches; supported by sedges woven into side or in shrubs; of grass, sedges and weed stalks lined inside with finer grass and rootlets--Red-winged Blackbird.

II. Nests on ground or in grass clump or rarely in low shrubs less than 18 inches above the ground.

1A. Nest on the ground, often in a hollow.

2A. Outside diameter more than 7 inches.

3A. Lined with feather down.

4A. Usually near water; of sedges, grass and leaves; down is dark gray or sepia with conspicuous white centers and faintly indicated whitish or light brown tips--Mallard.

4B. In a hollow in ground, often on uplands; built of fine grass and lined with light brown to drab down with large whitish centers--Blue-winged Teal.

3B. Not lined with feather down; a hollow, scantily lined with leaves and grass---Ring-necked Pheasant.

2B. Outside diameter 7 inches or less.

5A. Usually with a dome-shaped roof woven of grass; sometimes with covered tunnel leading to nest; well-concealed and difficult to find.

6A. Usually less completely roofed, sometimes merely built under an overarching grass clump; nest hollowed out and lined with dry grass, leaves or weed stalks; outside diameter 5 to 7 inches and outside height 2½ inches--Bobwhite.

6B. Dome-shaped roof of dry grass woven into growing grass and plants; outside diameter 6½ inches and outside height 7 inches--Eastern Meadowlark.

5B. Not with a woven roof; may be built under an overarching clump of grass.

7A. Cup-shaped and hollowed under a grass clump; lined with rootlets, fine grass and/or hair; outside diameter 4 inches and inside diameter 2½ inches--Lark Sparrow.

7B. Cup-shaped on the ground usually beneath shrubs near water; loosely put together of coarse grass, weed stems, dried leaves and bark strips; lined with fine grass, tendrils, rootlets and/or hair; outside diameter 3¼ inches and inside diameter 1 3/4 inches--Yellowthroat.

1B. Nest usually built in a grass clump and supported a few inches off the ground by the grass to which it is attached; rarely in a low shrub. (The following two nests cannot usually be distinguished).

8A. Inside diameter 2 inches and inside depth 1½ inches; cup-shaped of coarse grass, weed strips and rootlets; lined inside with finer grass and/or hair--Field Sparrow.

8B. Inside diameter 2½ inches and inside depth 1 3/4 inches; cup-shaped of grass, leaves, weed stems and rootlets; lined inside with finer grass and/or hair--Dickcissel.

III. Nests in holes in a tree. These nests will not be examined in this investigation. The following birds nest on Sand Prairie Reservation in holes in trees: Common Flicker, Red-bellied Woodpecker, Downy Woodpecker, Hairy Woodpecker, House Wren, Black-capped Chickadee, Eastern Bluebird and Great Crested Flycatcher.

IV. Nests floating on water in sedges or flooded shrubs. These nests will not be examined in this investigation. The following birds build floating nests on Sand Prairie Reservation: Pied-billed Grebe and American Bittern.

Dwight Platt

Module 18: Is there a pattern in the distribution of plants in a prairie?

Age level: High school

Subject: Biology

Theme: Diversity

Sequence: Field Trip

Prerequisites: Modules 1 and 2; Module 11 is also recommended

Objectives: To observe plant zonation and to express the pattern quantitatively; to proceed from the observation of a zonation pattern to the formation of hypotheses to explain the pattern; to understand how the zonation of plants increases the diversity of a natural community and how this contrasts with cultivated man-managed communities

Best season: Any season, but best in summer and fall

Time required: Approximately 1 to 1½ hours on Sand Prairie Natural History Reservation (if optional parts of the investigation are done, it may require 2 hours)

Materials required:

50-foot lengths of light rope - one for each group of students
Stakes - two per group of students

For optional parts of the investigation:
Two thermometers (standardized with one another)
Anemometer
Light meter
Trowel
(Some of this equipment may be available on loan from SKEEC)

Investigation

Part I. Preparation

The following species of plants are well adapted for this study of distribution:

1. Little Bluestem Andropogon scoparious - common on uplands
2. Switchgrass Panicum virgatum - common in lowlands
3. Fourpoint Evening Primrose Oenothera rhombipetala - common on uplands
4. Silky Prairieclover Petalostemon villosum - common on uplands
5. Johnny-jump-up Viola rafinesquii - common in lowlands
6. Common Prickly Pear Opuntia compressa - common on uplands
7. Puccoon Lithospermum caroliniense - common on uplands
8. Slender Goldenweed Haplopappus divaricatus - common on uplands

Before the field trip, the teacher should visit Sand Prairie Reservation with personnel from SKEEC to select a sand ridge for study and to become familiar with the plants that will be investigated.

Part II. Introduction to the field investigation

When the class arrives at Sand Prairie Reservation, proceed directly to the top of the sand ridge chosen for study. Introduce the study by making some of the following points:

1. Plants in a garden or in a cultivated field grow in an obvious pattern established and maintained by human management. Without human management in a natural area, one might expect that plants would grow by chance or with a random distribution.

2. However, in a natural community, the patterns are usually not random. Ask the students to point out some patterns they observe in the distribution of the plants around them.

3. The first step in understanding plant distribution is to describe it. When students point out a distribution pattern, ask them to describe it as precisely as possible.

4. After a few examples have been pointed out, suggest that observations need to be quantified in order to make precise descriptions that allow comparisons to be made.

5. The most precise description of the distribution of a plant on the slope of the sand ridge would be a complete count of the number of plants in each altitudinal zone. However, this would require much work and is probably more precise than necessary.

6. In order to reduce the work, counts on smaller sample areas can be made. If the samples are chosen in the same way in each altitudinal zone, the counts can be compared.

7. If the data collected is to be compared statistically and used to estimate the density of a species of plant on different parts of the ridge, a number of sample areas must be counted in each zone, and the sample areas must be selected by random methods. This would require more time than is available on this field trip.

8. For the study on this field trip, plants in one representative sample area will be counted in each zone being compared. This will allow a quantitative expression of the distribution pattern. However, point out that no statistical determination of its accuracy can be made nor can statistical comparisons be made.

Part III. Investigating plant distribution

Divide the class into groups of 4 students. Give each group a 50-foot length of rope and two stakes. Assign one species of plant to each group and show them how to recognize it. Explain that the sample areas will be the area intercepted by a 50-foot length of rope when it is stretched.

One sample area will be counted on top of the ridge, one sample halfway down the slope, and one sample at the bottom of the slope. Since only one sample area will be counted in each zone and the data cannot be used for statistical interpretation, no attempt will be made to locate the sample areas randomly. Rather, the students should select a site to stretch the rope that appears to be typical of the zone being sampled. The rope should be stretched at right angles to the slope (not up and down the slope) so that each sample count is from one height on the slope.

At each site chosen, the rope will be stretched tightly and fastened at either end to a stake. The students will count each individual of the plant species assigned to them that is intercepted by the rope. Before they start, each group must decide on a method of counting that will be used consistently with all samples. For some species, like Johnny-jump-up, the counting of plants intercepted is an easily defined task. For other plants, like Little Bluestem, it is not so obvious what is to be counted. Each individual stem intercepted can be counted or the number of bunches can be counted. Or instead of counting plants, the group can measure the length of rope intercepted by plants if a ruler is available. Each of these is a valid measure but each describes a different aspect of the importance of the species of plant. The important thing is for the group to use a consistent method.

Part IV. Discussing the investigation

After the groups have collected their data, call the class back together. Ask the first group to report their results. After they have given their data, ask them to make a general statement about the pattern of distribution of the plant. Discuss the adequacy of their statement and point out that it is important to provide information that will allow a person hearing the description to judge its reliability. Discuss the adequacy of statements of the form, "Plant A is three times as common on the ridgetop as it is on the midslope and twice as common on midslope as it is at the bottom of the slope," and compare to statements of the form, "On the basis of three representative samples, we conclude that species A is approximately three times as common on the ridgetop as it is at midslope and twice as common at midslope as it is at the bottom of the slope."

Description of a distributional pattern is only the first step in understanding it. The next step is trying to answer the question, "What causes the pattern?" Ask this question of group 1. There are many possible answers (see Statement of Concepts). When a number of possibilities are suggested, point out to the students that they are guessing the answer to the question on the basis of a limited amount of evidence. This is known as constructing hypotheses and is an important step in a scientific investigation. No explanation can be investigated until it is first stated as a hypothesis.

(optional). If students suggest that the differences in plant density are related to differences in certain physical factors such as temperature, soil water, wind, etc., you can ask them to determine if such differences in physical factors are present right now. However, point out that this is simply further evidence on the validity of a hypothesis. Finding similar patterns in physical factors and plant distribution does not prove that one is the cause of the other. The similarities may be coincidental.

The next step after formation of a hypothesis is to test it by experimentation. You can ask the class to suggest the design of an experiment that would test one of the hypotheses that has been suggested. Or you can wait until you get back to the classroom and then ask each group to design on paper an experiment to test each of the hypotheses that they had suggested.

After the distributional pattern described by group 1 has been discussed, you can proceed to consider the data of each of the other groups. Compare the distributional patterns.

After you have considered all of the distributional patterns that have been studied, point out that such zonation patterns allow a plant to develop adaptations to most efficiently exploit the zone in which it is most successful.

Discuss the differences between plant distribution patterns that were found in this natural community and those in a cultivated field. In a cultivated field, the pattern is one of uniform spacing, but the same plant grows on the uplands and lowlands. Discuss the advantages and disadvantages of each of the distributional patterns for: 1) human agricultural purposes, and 2) the function of a natural community.

Which of these communities has greater plant diversity? Would it be more diverse in number of species or in equitablity of distribution or both? How does zonation contribute to diversity? You may want to continue this discussion back in the classroom.

Statement of Concepts

An important plant distribution pattern in a natural community is zonation. On any given area, environmental features differ slightly or greatly on different parts of the area as a result of changes in topography, drainage, soils, etc. Plants are adapted to grow best and successfully survive under certain conditions and in association with certain other plants and animals. Therefore, plants of a particular species tend to be most dense where conditions are most favorable. This results in a zonation of the vegetation. Zonation does not necessarily mean that plant communities replace one another in discrete fashion. Different species may have their own patterns of change along an environmental gradient.

The slope of a sand ridge has a maximum change in physical environmental features. Therefore, the plant species are distributed in a very regular way and it is an excellent area for studying plant zonation.

Some of the possible causes for plant zonation on the slope of a sand ridge might be:

1. Zonation of physical features
    a. Ground water availability - rain water percolates rather rapidly through the sand, leaving the plants on the upland with a shortage of water in dry seasons. Ground water may collect near the surface in the lowlands, particularly since there is a rather impervious subsoil below the sand.
    b. Temperature - temperature extremes may be greater on the top of a south slope where the sun shines more directly during the day.
    c. Frost - some lowland areas may have a later killing frost in the spring and an earlier killing frost in the autumn because the cold air tends to sink into low pockets at night.

d. Wind - wind movement may be greater on top of the ridge than in the more protected lowlands.

e. Nutrients - nutrients may be leached rapidly out of the sand on the upland ridge in percolating water but may be more available in the lowlands where water collects.

f. Flooding - lowland areas may be flooded periodically, while upland ridgetops are never flooded.

2. Competition with other plants - a plant may be more common on the ridgetops, not because it cannot grow well in the more moist lowland environment but because it cannot compete with other plants that grow more successfully there.

3. Conditions created by the community - plants can make better growth in the moist lowlands which results in greater litter collection and more organic matter in the soil. This may be favorable or unfavorable to the growth of a particular species.

4. History of the area - the sand ridge has grown in the past by deposition of wind-blown sand. There may have been less time for the colonization of the ridgetop by plants since it was more recently moving sand.

A natural prairie would usually be more diverse than a cultivated field in both the number of species and the equitability of their distribution. If you searched carefully in a cultivated field, you could probably find a fairly long list of plant species, but all of them except the one species of cultivated plant would be comparatively rare in a well-managed field. For further discussion of diversity and its components, see the Statement of Concepts in Module 2 or read the article by Watt (1972).

In a natural prairie, the zonation of physical features determined by the topography of the area creates many different ecological niches for plant species. A plant species can become best adapted for one or a few of these niches, and other niches are available for colonization by other plant species. This makes it possible to have a higher diversity both in number of species and equitability of distribution. It also allows each plant species to become specialized to best exploit the resources of its niche and in this way the ecosystem is most efficient in the use of resources.

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Dwight Platt

Module 19: What do grasshoppers eat?

Age level: High school

Subject: Biology **Theme:** Diversity

Sequence: Field trip **Prerequisites:** Modules 1, 2 and 6; Module 11 is also recommended

Objectives: To study diversity in food eaten by similar species; to determine if the species of grasshoppers in a prairie divide the potential food resources into many food niches; to observe how specialization for a food niche affects the structure of mouthparts

Best season: May to October; best in late summer and fall

Time required: At least 1 hour at Sand Prairie Reservation; 2 hours in the classroom observing collections and discussing the results

Materials required:

Insect nets - one for each group of students (few available on loan from SKEEC)
Insect killing jars (available on loan from SKEEC)
Microscopes or strong hand lenses (at least 10X to 20X magnification; to be used in the classroom)
Modeling clay
Fine forceps or tweezers
Small plastic bags - one for each group of students
Slide-tape set #9: "Grasshopper Mandibles" (available on loan from SKEEC)

Investigation

1. Before the field trip to Sand Prairie Reservation, raise and discuss the following questions, but do not answer them:

   a. What do grasshoppers eat?

   b. Do grasshoppers eat everything that is green?

   c. Do all grasshoppers eat grass?

   d. How many different species of grasshoppers would we expect to find in a prairie?

   e. If there are many different species of grasshoppers living in a prairie, would they compete for food?

   Ask for suggestions on methods for finding out what grasshoppers eat. Three possibilities might be:

   a. To observe grasshoppers feeding naturally in the prairie

   b. To see what foods grasshoppers will eat in captivity

   c. To study the structure of the mouthparts to see if they provide any evidence on the type of food eaten.

If the students don't think of the last alternative, you may have to suggest it. Point out that grass stems and leaves have much more silica in them than is in the leaves and stems of broad-leafed plants (forbs). This makes them more abrasive to chew. Also, grasses have more layers of hard fibrous cells (sclerenchyma) that are difficult to chew. Also point out that insects feeding on small seeds must have structures for getting at these seeds and getting them out of the fruiting structures. Animals that eat other animals must have structures for catching and holding prey. Suggest that an investigation be made on a field trip to Sand Prairie Reservation to see how many different species of grasshoppers can be found in the prairie and to try to get evidence by the first and third methods listed above on what these grasshoppers eat. Ask each student to take a notebook on the field trip to record information. You may want to prepare forms for their use in recording information.

2. When you arrive at Sand Prairie Natural History Reservation on the field trip, divide the class into groups of 3 or 4 students and give each group an insect net, an insect killing jar, some pieces of paper in which to wrap the grasshoppers that they catch, and a small plastic bag in which to place the specimens. Point out the area in which they are to carry on the investigation and indicate the time or the signal for coming back together after the investigation. Indicate where you will be if they have questions. Point out an example of poison ivy and warn them to be careful of it when they are in or near willow groves. Ask each group to do the following:

   a. Record each new kind of grasshopper they find. It is not necessary to determine the name of each kind. Determine whether it is a long-horned grasshopper with antennae as long as or longer than the body or a short-horned grasshopper with antennae much shorter than the body. Designate all long-horned grasshoppers "L" and then give each kind a number (L1 would be the first kind of long-horned grasshopper caught). Designate all short-horned grasshoppers "S" and then give each kind a number. Record the letter and number designation for each kind in notebooks along with characteristics in which that kind differs from all other kinds found. (Point out that new kinds should not be based on differences in size or completeness of wings because these are characteristics of development stages. You may want to ask them to ignore grasshoppers with body lengths less than 1/2 inch if plenty of large grasshoppers are available).

   b. Catch one specimen of each kind of grasshopper observed. It should be killed and then wrapped in a paper with the letter and number given that kind of grasshopper written prominently on the paper. Emphasize that the grasshopper should be left in the killing jar at least 5 minutes after it stops moving to be sure that it is dead.

   c. Record in their notebooks the kind of plant--grass, forb, shrub, or tree--on which each grasshopper is found. The plant recorded should be the one on which it is found before it is disturbed. Try to observe some grasshoppers without disturbing them; and if they observe a grasshopper feeding, they should record the kind of food it is eating--leaves or stems of grass, leaves or stems of forbs, leaves of shrubs or trees, seeds, or other insects. Emphasize the importance of making careful observations and always recording the kind (letter and number given to that kind) of grasshopper to which an observation pertains.

After the students have made their observations and collections, check that all of the insect nets and killing jars are accounted for before returning to the classroom.

3. First catalog the number of species of grasshoppers that have been observed and collected. Place a table like the following on the chalkboard:

	Numbers Given by				
Class No.	Group 1	Group 2	Group 3	Group 4	Etc.
L1					
L2					
Etc.					

Ask group 1 to list the kinds of grasshoppers they observed and collected, and for each kind to read the distinguishing characters and show the specimen. The class should decide for each kind listed whether it really is a separate species. Also, each group of students should check whether they collected the same kind and, if so, should list the number they gave to it. Where there is a question, compare the specimens that have been collected. Then ask group 2 to list the kinds they collected that were not collected by group 1. Continue until all the different species of grasshoppers collected by members of the class have been listed.

4. Study the mandibles of the grasshoppers that have been collected to see if they differ in grasshoppers that eat different kinds of foods. Have each group of students take one of the largest short-horned grasshoppers they have collected. Give to each group of students a low-power microscope or hand lens, a small piece of modeling clay, and a forceps or tweezers. Use the tape recording and set of slides on grasshopper mandibles which are available on loan from SKEEC to give instructions to the class. This audio-visual aid will show:

a. How to find the mandibles

b. That the left mandible overlaps and therefore is somewhat different from the right mandible

c. How to remove the mandible and mount it in clay for observation

d. How to recognize the incisor and molar lobes of the mandible

e. The characteristics of the three types of mandibles found in short-horned grasshoppers.

Each group should then determine what type of mandible is present in each kind of short-horned grasshopper they have collected. For each one they should examine primarily the left mandible. The types are:

Type 1. The cutting edge of the incisor lobe is jagged and has a number (often 4) of well-defined teeth or dentes. The molar lobe includes a number of well-defined sharp teeth or dentes irregularly arranged with smaller or larger concavities between.

Type 2. The cutting edge of the incisor lobe is more continuous with the teeth or dentes only marked off by shallow grooves. The molar lobe consists of a regularly arranged series of ridges and grooves.

Type 3. These are variable and intermediate between types 1 and 2. For instance, the molar lobe may have separate teeth but they may be arranged in a pattern resembling grooves and ridges.

After the students have finished classifying the mandibles of short-horned grasshoppers they collected, continue with the tape recording and slides to demonstrate the types of mandibles found in long-horned grasshoppers. Then have the students classify the mandibles of long-horned grasshoppers that they collected. The types are:

Type 1. The cutting edge of incisor lobe is jagged with well-separated pointed dentes (usually 3). The molar lobe is smaller than in mandibles of short-horned grasshoppers but has separate dentes irregularly arranged.

Type 2. Mandible is elongate and narrow. The tip of the incisor lobe has a larger narrow chisel-shaped tooth. The molar area is not large and is covered with tubercles.

Type 3. Mandible is elongate and narrow. The 3 dentes of the incisor lobe are partially fused and are extended to form a sharp cutting or grasping hook at the tip. The molar lobes are much reduced.

After the students have finished classifying the mandibles of all the grasshoppers they collected, see how many of the different groups have mandibles falling into each of the types. Did different groups classify the mandibles of the same species in the same way? As you consider each of the types of mandibles and the species that have them, discuss the significance of the structure of the mandibles and the type of food they would be most adaptive for handling. Let the students give their ideas but point out the following if they do not suggest them:

Short-horned grasshoppers:

Type 1. Found in grasshoppers that primarily eat the leaves and stems of forbs; adapted for cutting and crushing the relatively soft tissues.

Type 2. Found in grasshoppers that primarily eat grass; adapted for cutting and grinding the tougher and more abrasive tissues.

Type 3. Found in grasshoppers that eat both forbs and grass but usually prefer one or the other.

Long-horned grasshoppers:

Type 1. Found in grasshoppers that eat leaves and flowers of forbs; adapted for cutting and crushing the relatively soft tissues.

Type 2. Found in grasshoppers that primarily eat seeds; the tip of incisor lobe is used to pull seeds out of fruiting structures.

Type 3. Found in grasshoppers that primarily eat insects; the tip of the incisor lobe is used to catch and hold prey.

Have each group of students read the notes they made recording observations of feeding in grasshoppers. Are the observations consistent with the type of mandibles the grasshopper possesses?

Discuss what you have learned about grasshoppers in a prairie. Discuss again the questions at the beginning of this exercise. Can you give better answers to them now?

(optional). Take another field trip to an ecosystem with less diverse food resources. A crop field--wheat, corn, alfalfa--would be good. Repeat the above exercise there. Collections and observations should be made in the interior of the field and not around the edge. Compare the data collected on the prairie with that collected on the crop field in terms of the diversity of grasshoppers and of their feeding types. Does simplification of the plant community have an effect on the diversity of animals that consume plants?

Statement of Concepts

For two similar species of grasshoppers to coexist in a prairie, they must have ecological niches that are different enough to reduce competition between them. Each species of grasshopper becomes specialized for exploiting certain resources and conditions. One resource that can be subdivided into a number of niches is food and each species may most efficiently utilize a certain group of foods. Such specialization may not only involve differences in behavior and physiology but also in the structure of parts that are used in feeding.

Such a specialization of species for rather narrow niches allows a diversity of species to coexist in one environment. However, if the specialization becomes too narrow, the species may be unstable. Any small change in the environment, like the disappearance of one species of plant that is the only food source for an animal species, may result in the inability of the species to continue to exist in that community. However, if the niche is very broad and generalized, then only one or a few species can coexist in the community to exploit the resources and, if anything happens to one species, it has an important effect upon the balance in the community. In a community with an optimum diversity, there may be many similar species, like the many species of grasshoppers in a prairie, with some overlap of niches but with each specialized enough to reduce the areas of competition. This diversity of species can most efficiently exploit the resources of the community and, if one species is reduced in numbers, other species can expand their niches to exploit the resources that had been utilized by the species that became rare.

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Dwight Platt

Module 20: Why is it colored orange?

Age level: Upper elementary and junior high

Subject: Biology **Theme:** Interdependence

Sequence: Field trip **Prerequisite:** Module 5 or 6

Objectives: To study the interdependence of the coloration of an insect or a flower with its ecological relationships to other organisms; to see how the color of an animal or flower may be an adaptation for successfully living with other organisms; to learn that scientific observations must be limited and planned in order to get evidence for or against hypotheses

Best season: May to October

Time required: At least 1 hour at Sand Prairie Reservation; at least 1 hour in the classroom before the field trip discussing the study and at least 1 hour in the classroom after the field trip discussing the results. This module describes two investigations of color -- in insects and in flowers. For younger students, the field trip should be limited to one of the investigations and the time can be shortened somewhat.

Materials required:
Slide-tape set #10: "Color in a Prairie" (available on loan from SKEEC)
Illustrated booklet of insects with yellow, orange, or red coloration (available on loan from SKEEC)

Investigation

Part I. In the classroom

1. Use the slide-tape set, "Color in a Prairie," to introduce this study. Utilizing questions and discussion, review with the class the functions of color for animals and plants as they were presented by the recording and slides:

    a. Coloration is sometimes related to the ability to absorb and use the energy of sunlight or to gain protection from the radiant energy of the sun.

    b. Color patterns may make an animal less visible to protect it from other animals that would eat or harm it.

    c. Color patterns may make an animal or flower more visible to attract or repel animals.

2. After a short review, stop the discussion and ask the class if they would like to investigate the function of color in a prairie. Tell them about the planned field trip. Point out that color may have many

functions and all of these functions cannot be studied on a short field trip. The first task of a scientist is to limit and define a study so that observations can be made to answer one or a few questions. Suggest that on this field trip, the class study the third function of color, making an animal or flower more visible.

3. Ask the class what colors would be most visible in a prairie. In order to help them answer this question you can ask what colors people wear when they want to be visible, for instance men working on a highway or hunters when they need to be visible to other hunters. Or what colors are used on objects that need to be very visible, for instance important safety signs on a highway. The class will probably agree on red, orange, and/or yellow.

4. Suggest that the class investigate the function of color in increasing visibility of two different groups of organisms on the prairie -- insects and flowers:

   a. What insects have patches of red, orange, or yellow color? How can extra visibility help these insects? Ask for possible answers to the last question and point out that these answers are guesses. When scientists make guesses about the answer to a question, they call these guesses hypotheses and then plan how they can test whether they are true. Some possible hypotheses to answer the above questions are:

      (1) Attracting a mate of the opposite sex.

      (2) Repelling other individuals of the same species that might eat its food or in other ways compete with it.

      (3) Startling a predator by flashing a bright pattern. The predator may pause momentarily and the insect with the flash pattern may sometimes escape.

      (4) Signaling to predators that the insect is distasteful, poisonous, or has a sting, and thereby discouraging attempts to eat it.

      (5) Mimicing the signals of distasteful or poisonous insects as a protection from predation.

      (6) Red, orange, or yellow coloration may not make the insect more visible but rather tend to camouflage it, if it is usually found on a red, orange, or yellow background (for instance, on a flower).

   Point out that these hypotheses are not mutually exclusive, but all could be true in different situations. This makes the attempt to prove or disprove these hypotheses very difficult because they may apply in some situations but may not apply in many others. Put the questions and hypotheses on a poster or on the chalkboard where the class can refer to them after the field trip.

   Now plan observations on a field trip that might provide evidence for or against some of these hypotheses. Emphasize that the purpose of the field trip investigation is not to prove or disprove any of the hypotheses but to gather some evidence in order to decide which might be the best hypothesis to test by experimentation and further observation. Observations to be recorded on the field trip are underlined below. You may wish to modify these on the basis of suggestions by the class. Suggest that on the field trip the class look for and make a list of the insects that have red, orange, or yellow coloration. It may be difficult to get evidence for or against the first hypothesis on a short field trip, so you may want to leave that hypothesis untested.

To get evidence for or against the second hypothesis, the class can record for each insect observed whether it is observed alone or in a group, with other insects of the same species close by. Point out that if the insects are mostly observed alone, it is consistent with the hypothesis that the color repels others of the same species but does not demonstrate that that is so. If the insects are usually found in groups, the color does not have a repelling effect in the observed situations, but this does not preclude the color functioning in that way in some other situation.

The third hypothesis implies that the bright colors are normally hidden but can be "flashed" in escaping from a predator. To obtain evidence supporting this hypothesis, the class can record in which insects the bright pattern is normally hidden and can be "flashed," and in which insects it cannot be hidden.

The fifth hypothesis can only be true if the fourth hypothesis is true. However, if color is to serve as a signal of unsuitable prey, then a large number of the insects with these colors should be distasteful or poisonous. Otherwise the predators will not learn the meaning of the signal. To get evidence for the fourth hypothesis, suggest that the class study the list after the field trip to see how many of the insects might be distasteful or poisonous in some way. If the fourth hypothesis seems to be a reasonable explanation of the color of some of these insects, then the fifth hypothesis might be a reasonable explanation for coloration of some of the red, orange, or yellow insects that are not distasteful or poisonous. (Information with regard to these characteristics of red, orange, or yellow insects will be found in the booklet borrowed from SKEEC).

To gain evidence for or against the sixth hypothesis, the class can record how many times each kind of insect was observed on a red, orange, or yellow background and how many times on a background of another color.

b. Flowers need to be visible to attract pollinating animals. Why aren't all flowers colored red, orange, or yellow to be most visible? A hypothesis that would answer this question is: All animals that pollinate flowers don't see the same colors. Some animals, almost certainly animals that pollinate flowers at night, may be color blind and, therefore, a contrast in color would not necessarily make the flower more visible. The eyes of some animals may be very sensitive to red or orange light while the eyes of other animals might have low sensitivity to orange or red but have higher sensitivities to other colors.

Now plan observations that will provide evidence for or against this hypothesis. If this hypothesis is true, flowers of different colors should have different animals visiting them for nectar or pollen. Suggest that the class find flowers of different colors and, for each, record what kinds of animals visit the flower to collect nectar or pollen in a few minutes of observation. They can be recorded as: bees or wasps (2 pairs of wings), flies (1 pair of wings), butterflies or moths, etc., and each can be briefly described.

Part II. In the field

On the field trip, keep the class together as one group if it is small. If the class has more than 20 students, it is better to divide into two groups, each with an adult leader.

Each student in the group should be given an assignment. Some can be recorders. You may want to prepare forms on which they can record the various types of observations. Some students can be searchers for red, orange, and/or yellow insects while others can be searchers for flowers of different colors. When a student finds something to be observed and recorded, however, draw the attention of the whole group to it but keep them from disturbing the student making the observation or the animal being observed. When a red, orange, or yellow insect is found, identify it, if possible, by reference to the illustrated booklet borrowed from SKEEC. Insects not found in the booklet should be identified only in a general way and briefly described in the record.

Part III. In the classroom

After the field trip, discuss the observations that have been made and determine if there is evidence for or against any of the hypotheses.

1. Study of red, orange, or yellow insects

Call attention to the questions and the list of hypotheses that had been discussed before the field trip. Point out that the first hypothesis was not tested.

Second hypothesis: List the kinds of red, orange, or yellow insects on the chalkboard. For each kind, total the number of times an individual was observed alone and the number of times a group was observed. Did anyone observe other evidence of one individual repelling another--aggressive behavior, chasing, one individual leaving when another arrived, etc? For how many of the kinds did you get no evidence that color might be used to repel others of the same species? If you were going to perform experiments to test this hypothesis, which kinds of insects would you select for your experiments? Have the class briefly talk about how such experiments might be done.

Third hypothesis: Did the class find any examples of insects that flashed a bright red, orange, or yellow pattern when they tried to escape? How could you test this hypothesis to see if the flash pattern was of any value to the insect in escaping from predators. Point out to older students that the insect may often be caught by the predator, but the flash pattern may still be of value to the species if it allows some individuals to escape that otherwise would not.

Fourth and fifth hypotheses: Consulting the booklet on red, orange, and yellow insects, or other references, list for each species observed whether it is known to be distasteful or poisonous or to possess a sting. Point out that the distasteful or poisonous nature of many insects may not be known. What percentage of the red, orange, or yellow insects observed (excluding those that only have hidden flash patterns) are known to be distasteful or poisonous or to possess a sting? Does this percentage seem high to the class? You may want to discuss further the nature of signals and of mimicry (see Statement of Concepts). Are your observations consistent with the hypothesis that these colors may be warning signals in some situations? Are there insects observed that might be mimicing these signals? On the basis of these observations, would it be profitable to try to get direct evidence that orange coloration discourages predation? Have the class discuss what sort of experiments might be performed to get direct evidence for this function.

Sixth hypothesis: Total the number of times each kind of insect was observed on a red, orange, or yellow background and how many times on a background of another color. Is there any evidence that these colors are used as camouflage for some of the insects observed? Would your observations be a fair indication of the number of insects on these two backgrounds? Why not? Are there any experiments that could be done to test this hypothesis?

2. Study of the color of flowers

List on the chalkboard the various colors of flowers seen. For each color, list the number of various kinds of insects that visited the flowers under observation. Do different colors of flowers have different kinds of insect visitors?

Experiments have shown that the eyes of honeybees have low sensitivity to red and orange while the eyes of some butterflies are highly sensitive to reddish colors. Are your observations consistent with these experiments?

Point out some of the factors that were not considered in your observations. Some pollinating animals might be attracted to flowers more by odor than by vision. Some flowers may have colors that we do not see but which other animals see. The eyes of honeybees are sensitive to ultraviolet which we cannot see. Show the photographs on page 41 of the article by Livaudais (1974) to the class. The top photograph shows the flower as a bee might see it.

3. What have we learned from this study? You should emphasize the following points in discussion:

   a. We have assumed that color patterns have a reason. Scientists have shown that most structural patterns of animals and plants have an adaptive reason--they make the animal or plant more successful.

b. We have discussed some possible explanations of certain color patterns, what a scientist would call hypotheses. We have made some observations which are consistent or not consistent with some of these hypotheses. We have not "proved" nor "disproved" any hypotheses. However, we have discussed how we could get more evidence to support some of the hypotheses.

c. These hypotheses are not mutually exclusive. There may be more than one explanation for a color pattern. However, certain explanations may be applicable in more situations. The explanations of many of the color patterns we observed have not yet been studied in detail by scientists.

d. The color patterns of an animal or plant are, in many cases, related to the interdependencies of organisms in an ecosystem. Such interdependencies are not only important to an ecosystem, but they have affected the structure (i.e., color) of organisms in the ecosystem.

4. For which of the hypotheses did you get the most supporting evidence? Would the class like to follow up this field trip by experimenting with this hypothesis? If so, have the class design some experiments that they can do. Module 34 gives ideas for follow-up experiments that can be used.

Statement of Concepts

Most structural characteristics of animals and plants are adaptive; that is, they contribute to the successful survival of the individual. Color is such a characteristic. Color results from the absorption of certain wave lengths of light and the reflection of other wave lengths by chemicals we call pigments. This may be important to some organisms in the utilization of light or protection from light. The use of the green pigment, chlorophyll, in capturing light for photosynthesis is a widespread example. Color may also serve a signaling function modifying the relationship between organisms.

Red, orange, and yellow are very visible in the natural environment to most vertebrates with color vision because they contrast with the predominant blues and greens and because the vertebrate eye with color vision is usually quite sensitive to reds. This is true of birds which are important predators on insects. Most insects need to escape detection in order to survive. You will note that the majority of insects are brownish, greenish, or black to escape detection. Some have very elaborate patterns to mimic their background and provide camouflage. But some have bright red or orange patterns that seem to signal, "Here I am! Recognize me!" These may be used by insects as a warning to predators.

If a bird eats an insect with an orange color pattern and finds it distasteful, it may associate the bad taste with the contrasting color pattern. In fact, it may need to eat only a few insects of this kind before it learns to avoid insects with an orange color pattern and not to taste them. All insects with an orange color pattern would then gain some protection from predation. Some insects can mimic these distasteful insects and give false warning signals and thereby gain protection. However, if mimics are very munerous, the predator will often eat mimics in a learning situation and will not learn to associate color with bad taste. Then neither the mimic nor the distasteful insects get protection. In order for such warning signals to function, false signals must be much less numerous than true signals. Also it would be adaptive for a number of species of distasteful or dangerous insects to have similar signals, because that would reinforce learning of the signal by the predator. The many species of bees and wasps with orange or yellow bands might be an example.

Some insects are protectively colored in browns or grays to escape detection, but have an orange patch that can be flashed to startle a predator if they are detected. This may cause the predator to pause momentarily and allow the insect with the flash pattern to escape. The Underwing Moth would be a good example of this.

Warning or flash signals do not need to be effective in all situations or with all predators. If they allow some individuals to escape that might otherwise be eaten, they are of value to the species.

Red, orange, or yellow colors are probably less often used to attract mates or defend territories in insects. Many insects see these colors poorly and they appear simply as gray or black which would not make a contrasting signal. These colors may be important in attracting mates or defending territories in some other animals such as birds.

The accessory parts of a flower have the important function of attracting animals as pollinating agents. If vision is important for the pollinating animal, it is important that the flower be of a contrasting color that makes it very visible. However, different animals have eyes sensitive to different color ranges. Therefore, flowers are colored to be most visible to their most important pollinators. However, color may be of little importance if the pollinating animal has no color vision or is attracted more by odor than by sight. A flower may attract some pollinators by color and some by odor.

Colors as signals are important in communicating information from one organism to another with which it is interdependent. These interdependent relationships are so many and varied that only a few of them have been well-studied by biologists. Therefore, it is important to warn observers that particular explanations cannot be assumed simply on the basis of the presence of a particular type of color pattern. It usually takes experimental investigation to find the function of a particular color pattern. Such experiments must be designed to test the responses of a predator, another animal of the same species, a pollinator, etc. to the color pattern in question. To demonstrate that an orange color patch serves as an important warning device for a distasteful insect, an experiment must be designed to show whether or not potential predators learn to associate orange with bad taste and thereafter avoid orange-colored insects. People sometimes use observations like those made in this module to "prove or disprove" an idea. One objective of this module is to point out the pitfalls of doing this.

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Dwight Platt

Module 21: Small vertebrates of the prairie

Age level: Can be adapted to various age levels

Subject: Biology

Theme: Diversity and Interdependence

Sequence: Field trip

Prerequisites: Modules 1 and/or 5 or 6; Module 11; the film, "What Ecologists Do," is a useful introduction (available on rent from SKEEC)

Objectives: To see and become familiar with some of the many small terrestrial vertebrates of the prairie; to learn how the functions of these small vertebrates in the prairie ecosystem are diversified; to see how ecologists study animals in an ecosystem

Best season: Late April to early November is best; can be done in a modified fashion with small mammals during favorable weather in the winter. Check with SKEEC personnel to see when they can arrange this trapping.

Time required: 1 hour or more on Sand Prairie Natural History Reservation

Materials required:
Each student should have a notebook for recording information and observations

Activities

On Sand Prairie Natural History Reservation, investigations on the populations of small vertebrates are being carried on. Some of these investigations involve the trapping of small vertebrates, the observation and recording of data about these trapped individuals, the marking of these individuals and their subsequent release for later trapping. Two types of traps are used. One type of trap intercepts moving animals with a "drift" fence that leads them to an opening into the cage of a trap. No bait is used. The other type uses bait to attract an animal into the trap and then a door drops to close the entrance. The field trip will be led by personnel from SKEEC who will check some traps and show what animals have been caught and how they are handled. They will emphasize: 1) the role of these animals in an ecosystem and 2) the methods used by ecologists in studying animals in an ecosystem. If you have particular ideas you would like to have stressed, discuss this with SKEEC personnel before the trip.

1. Before the field trip, students should learn about some of the animals that they will see. Ask them what small vertebrates they might expect to find in a sandy prairie. If they don't know what vertebrates are, discuss this.

2. Assign different members of the class to look up information about some of the following animals, many of which may be seen on the field trip. You may want to consult SKEEC personnel to find out which of the listed animals are most likely to be found when you will be visiting Sand Prairie Reservation. Encyclopedias, nature encyclopedias, and the references listed at the end of this module (available in the SKEEC library) can be used. You may assign this report as a written exercise or as an oral report to the class.

   a. Leopard Frog Rana pipiens

   b. Tiger Salamander Ambystoma tigrinum

   c. Prairie (or Fence) Lizard Sceloporus undulatus

   d. Prairie Lined Racerunner Cnemidophorus sexlineatus

   e. Red-sided Garter Snake Thamnophis sirtalis

   f. Plains Garter Snake Thamnophis radix

   g. Bullsnake Pituophis melanoleucus

   h. Western Hognose Snake Heterodon nasicus

   i. Short-tailed Shrew Blarina brevicauda

   j. Harvest Mouse Reithrodontomys megalotis

   k. Woods (or White-footed) Mouse Peromyscus leucopus

   l. Prairie Vole Microtus ochrogaster

3. In planning with the class for the field trip, point out that scientists must record their observations in some way for later reference. Ask each student to take a notebook and pencil on the field trip to record observations. They should record those things pointed out by the leader that seem important. They should also record their own observations or thoughts about these animals.

4. On the field trip, the class should be divided into groups of approximately 10 students for the best learning experience. Usually it is not possible for SKEEC to provide leadership for more than three groups at once. So, if your class has many more than 30 students, check with personnel at SKEEC to see how they can best be handled.

5. Back in the classroom, discuss what you have learned on the field trip. You may ask each student to tell about that information or those observations recorded in his/her notes that seem most important to him/her. Discuss the animals that you have observed in the prairie ecosystem in one or both of the following ways.

   a. Discuss how each animal observed differs in its role in the prairie from other similar animals observed. Discuss how these differences allow more different animals to live in the prairie. Point out that differences in role reduce competition.

   b. Discuss how each animal observed relates to or interacts with other animals observed in this prairie. Do you find any predator-prey relations? Any competitive relations? (In some cases there may be no very obvious relationship). You may want to diagram some of these relationships on the chalkboard as they are discussed.

You will, of course, need to adapt these discussions to the age level of your students and explore ecological roles and relationships in more depth with older students. For older students, if you find questions that the class cannot answer, you may want to assign some students to do more reading or to contact authorities to see if they can find an answer.

It is never possible to predict what animals will be found and what observations will be made on a field trip such as this. If you need more information on animals or concepts to discuss the field trip with your class, consult with SKEEC personnel.

References

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Paul G. Jantzen

Module 22: What good is a weed?

Age level: Junior high and high school

Subject: Biology **Theme:** Interdependence

Sequence: Field trip **Prerequisite:** Module 6

Objectives: To clarify the meaning of the term "weed;" to consider the function of weed species in the ecosystem; to relate the niches of certain weedy forbs to their evolution; to understand the dependence of weeds on human disturbance; to assess humankind's relation to the natural world

Season for investigation: Whenever common weedy species are recognizable

Time required: About 1 to 2 hours for field work, 1 hour for follow-up written work in groups, and 1 hour for teacher - class discussion of written work

Materials required:

Notebook for each student for recording data

Wire rings made of heavy wire that retains its shape - one ring for each group of 2 to 4 students. (So that the wire encloses a 1 square meter area, it should have a circumference of 3.52 meters. Students may calculate this:

Area of circle $= \pi r^2 = 1.0\ m^2$; so, $r = \sqrt{\frac{1.0\ m^2}{\pi}}$

Circumference of circle $= 2\pi r = 2\pi \sqrt{\frac{1.0\ m^2}{\pi}} = 3.52$ m)

Activities

Part I. Preparation

You will need to become familiar with common weedy species before you can lead these activities. SKEEC personnel may be able to help with identification. Select several areas on which vegetation is frequently disturbed, such as edges of cultivated fields, roadsides, railroad right-of-ways, salt-lick or water supply areas for livestock, or overgrazed pastures. In addition, several areas in relatively undisturbed prairie should be located. You should identify the common, non-grass weedy species for students. Non-grass weeds are suggested because grasses are more difficult to identify.

Part II. Field activity

Divide the class into groups of 2 to 4 students. Without announcing the ultimate objectives of the investigation, students are told that they are making a weed survey in several selected areas. Their task is to determine the population density (in numbers per square meter) of common weeds in areas you have selected. In each area, the wire ring is placed in an appropriate location and all the plants of the main weedy species are counted. The count for each species is recorded. Accompanying the counts for each area should be a brief description of the area, including its location, use, and general condition. Supply the names of the common weeds encountered, either with slides, pressed specimens, or on-the-spot "labeling" as the work begins.

Part III. Classroom activity

The student groups should examine their data and should search for common elements in the distribution of weedy species. Students, individually or in groups, should supply written responses to the following questions. The questions may need to be selected and/or rephrased to adjust to the level of understanding of the class.

1. What kind of feeling does the word "weed" give you?
2. What is there about weeds that you don't like?
3. Define the word "weed."
4. In which of the plots you studied were the weeds most dense?
5. Consider the areas in which weeds were most dense. What do these areas have in common in terms of use, location, and general condition?
6. Where did the weeds that you found originate (on which continent, if not native to North America)? What significance might this have in understanding the evolution of weeds?
7. What characteristics do weeds possess that permit them to compete so successfully with our domestic plants?
8. Under what circumstances would one desire some of these weedy characteristics?
9. If weeds were not present, what would be present in their place?
10. What are some activities that weeds carry on in relationship to their environment?
11. Are any plants worthless to man? Are any plants worthless to the ecosystem?
12. What does your definition of the term "weed" reveal about the vantage point from which you view the world? Is this related to any of our environmental problems?

Part IV. Discussion

After students have individually and/or in small groups come to conclusions regarding the ten preceding questions, lead a discussion in which students share their responses. You may need to raise questions or suggest alternatives at various points during the discussion.

Statement of Concepts

Here are some possible responses for the above questions:

1. Student answer.

2. *Nebraska Weeds* lists 10 ways in which weeds cause losses to agriculture:

   a. Weeds rob the soil of nutrients needed by cultivated plants.
   b. Weeds take up moisture which might be used by cultivated plants.
   c. Weeds crowd out seedlings and smaller plants by shading.
   d. Some weeds grow parasitically on cultivated plants (dodder).
   e. Weeds harbor plant diseases and insect pests.
   f. Weeds injure livestock by means of barbed awns, hooks, and burs.
   g. Some weeds are poisonous to livestock.
   h. Weeds lower the value of agricultural seeds with which the weed seeds are mixed.
   i. Weeds make farms unsightly in appearance and reduce property loan values.
   j. Weeds make necessary large investments in machinery and increase labor costs in crop production, thus reducing net income.

3. Some definitions of "weed":

   a. Santelman (1970): "a plant that is troublesome and worthless where it is growing."

   b. Wherry (1948): "a plant which tends to invade areas reserved for other kinds of plants which are deemed more desirable."

   c. Nebraska Division of Noxious Weeds (1952): "any plant that grows where it is not wanted."

   d. Baker (1974): "a plant is a weed if, in any specified geographical area, its populations grow entirely or predominantly in situations markedly disturbed by man (without, of course, being deliberately cultivated plants)."

4 and 5. Students should answer these questions from the data they have collected. Weeds, as defined by Baker (1974), grow predominantly in situations disturbed by man. They may also inhabit areas disturbed by trampling buffalo, overgrazing, dung, drought, flooding, or certain fungi (see discussion of fairy rings by Costello, 1969). Does this correspond with the data collected?

6. Some common weedy species in prairies and disturbed places in south central Kansas, their flowering time, and their origin:

Annual Eriogonum *Eriogonum annuum*	July - Sept	Native
Annual Sunflower *Helianthus annuus*	July - Sept	Native
Broomweed *Gutierrezia dracunculoides*	Aug - Oct	Native
Buffalobur *Solanum rostratum*	June - Aug	Native
Catnip *Nepeta cataria*	June - Sept	Eurasia
Chickweed *Stellaria media*	Mar - Nov	Europe

Cocklebur *Xanthium* spp.	July - Sept	Native
Common Speedwell *Veronica arvensis*	Mar - Sept	Europe
Corn Gromwell *Lithospermum arvense*	April - June	Europe
Daisy Fleabane *Erigeron strigosus*	May - Sept	Native
Dandelion *Taraxacum* spp.	Mar - June, Sept - Dec	Europe
Dock *Rumex* spp.	April - Nov	Eurasia
Field Bindweed *Convolvulus arvense*	May - Aug	Europe
Flower-of-an-hour *Hibiscus trionum*	July - Sept	Europe
Goatsbeard *Tragopogon pratensis*	June - Aug	Europe
Henbit *Lamium amplexicaule*	Feb - June, Sept - Nov	Eurasia
Hoary Vervain *Verbena stricta*	June - Sept	Native
Horseweed *Conyza canadensis*	June - Oct	Native
Ironweed *Vernonia* spp.	July - Sept	Native
Knotweed *Polygonum* spp.	June - Oct	Eurasia
Lamb's-Quarters *Chenopodium album*	June - Sept	Europe
Mexican Firebush *Kochia scoparia*	July - Sept	Eurasia
Mustards (a large group of several genera)	April - Sept	Eurasia
Pigweed *Amaranthus* spp.	June - Oct	Tropical America
Plantain *Plantago* spp.	May - Sept	Eurasia
Poison Hemlock *Conium maculatum*	June - July	Eurasia and Africa
Puncture Vine *Tribulus terrestris*	June - Sept	Europe
Ragweed *Ambrosia* spp.	July - Sept	Native
Smartweed *Polygonum* spp.	July - Oct	Native
Snow-on-the-mountain *Euphorbia marginata*	June - Sept	Native
Spreading Chervil *Chaerophyllum procumbens*	April - June	Native
Velvetleaf *Abutilon theophrasti*	July - Oct	Asia
Wavyleaf Thistle *Cirsium undulatum*	June - Aug	Native
Wild Lettuce *Lactuca* spp.	Aug - Nov	Europe
Yarrow *Achillea millefolium*	June - Oct	Eurasia

7. While weeds may be native to the area in which they live, Baker (1974) says that many weeds are immigrants in America, having evolved in areas with long histories of agriculture. Apparently they evolved to fill niches created by the continuous disturbances characteristic of agricultural practices. Cultivation of crops on a large scale is comparatively new in America and native plants have not had sufficient time to develop characteristics that make them a serious problem. Nor have native species had time to evolve characteristics allowing them to compete with these new immigrants. Weeds compete so successfully with our domestic plants because they possess those characteristics needed by plants to take advantage of disturbance situations.

   Baker lists the following characteristics expected in an ideal weed, one ready to take advantage of disturbances:

   a. Germination requirements fulfilled in many environments
   b. Discontinuous germination and great longevity of seed
   c. Rapid growth through vegetative phase to flowering

   d. Continuous seed production for as long as growing conditions permit
   e. Self-compatible but not completely self-pollinating or asexual
   f. When cross-pollinated, unspecialized visitors or wind utilized
   g. Very high seed output in favorable environmental circumstances
   h. Produces some seed in wide range of environmental conditions
   i. Has adaptations for short- and long-distance dispersal
   j. If a perennial, has vigorous vegetative reproduction or regeneration from fragments
   k. If a perennial, has brittleness, so not easily pulled from ground
   l. Has ability to compete interspecifically by special means (rosette, choking growth, chemical inhibitors)

8. Some of these characteristics would be desirable for stripmining soil dumps, new highway right-of-ways, new earthen dams, etc., to protect the soil from erosion.

9. This question allows room for speculation and experiment. It may be that any species able to exist in such circumstances of disturbance would become a weed.

10. Many weeds, in various degrees, carry on the same functions as their more respected relatives.

    a. Weeds may bind the soil which might be more vulnerable to wind and water erosion in their absence.

    b. Weeds shade the soil, preventing higher temperature which might threaten soil organisms.

    c. Weeds convert solar energy, carbon dioxide, and water into organic compounds which may be used as food for herbivorous animals. (Lamb's-quarters, chickweed, and dandelions are good human foods).

    d. Weeds, when decomposed, provide mulch which enriches the soil and enhances its ability to absorb water.

    e. Weeds bring soil nutrients from subsoil to the surface, making them available to seedlings.

    f. Some weeds provide nectar and pollen for bees.

    g. Some weeds provide leaves, stems, roots, fruits, and seeds for wild birds, mammals, and other organisms to use as food and shelter.

    h. Weeds may play an important role in conditioning the soil as a disturbed area progresses toward a climax stage of succession. For some reason, this process requires a significant time span. This was illustrated in a study by Tomanek, Albertson, and Reigel (1955). After 33 years, an abandoned field in central Kansas had not yet reestablished its normal climax vegetation. Rice, Penfound, and Rohrbaugh (1960) found that the order in which certain species of seed plants invade abandoned fields in central Oklahoma was the same as the order based on increasing requirements for nitrogen. Perhaps weedy species play a necessary role in succession of disturbed areas that are abandoned because they differ in their survival needs. Perhaps the characteristics that make them weeds are exactly those which are necessary for survival in those stages of succession.

11. See number 9 above.

12. Many definitions of "weed" are based on man's priorities. Notice that the definitions in number 3 above use subjective ideas, such as troublesome, worthless, less desirable, and not wanted. The class might discuss the origins of this man-centered attitude and the dangers of this view. Have we, as inhabitants of overdeveloped countries, often viewed our natural resources as objects of exploitation that are limitless and only of value for our immediate use? What are the problems with this attitude? What changes would result if we learned to consider man as a component of our complex biosphere and interdependent with other components?

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Paul G. Jantzen

Module 23: Comparing two vegetated areas

Age level: High school

Subject: Biology **Theme:** Diversity

Sequence: Field trip **Prerequisites:** Modules 1 and 2

Objectives: To introduce one method of measurement and expression of plant population density; to compare canopy coverage and density of plants in a prairie and an area under human management, or in two areas under different human management; to speculate on causes of differences between the two vegetated areas; to become aware of problems in grassland management

Best season: Spring, summer, or fall

Time schedule:

Day 1. Introduce the study by distributing a student instruction sheet you have prepared and/or giving oral instructions for the study (from Part I, nos. 1 to 3) and by devising a method of randomly selecting the locations of sample plots.

Day 2. Visit both study areas to observe main plant species. (You will need to be familiar with the common plants; SKEEC personnel may be able to help you with identification).

Day 3. Quick review of general instructions and plant identifications with slides, specimens, or in-the-field "labeling." Data collection in the prairie.

Day 4. Quick review of plant identifications. Data collection in pasture.

Days 5 to 7. Analyzing and interpreting data (Parts II and III).

Materials required:

A rectangular frame of wire (about 40 cm. X 20 cm., sufficiently rigid to hold its shape) - one for each group of students
Either a set of slides illustrating the dominant plants of the study areas or a set of labeled, pressed plant specimens (very helpful but not mandatory)
Old calendar for plot placement determination
Copies of Canopy-Coverage Analysis Data Sheet (Supplement #1)
Copies of Canopy-Coverage Analysis Calculations Sheet (Supplement #2)

Investigation

Part I. Data collection

Divide the class into groups of 2 to 4 students for this investigation. As an introduction to the investigation on the first day, give the following instructions (nos. 1 to 3) to the students in oral and/or written form. On the third day, review these instructions and plant identifications and distribute copies of the Canopy-Coverage Analysis Data Sheet (Supplement #1) for recording data on the field trips to prairie and pasture.

1. Casual scanning of the landscape reveals obvious differences in vegetation. Sometimes the causes of those differences seem obvious, e.g., a body or stream of water, a steep slope, sandy soil, the climate, or the work of man. But at other times the water supply, slope, soil, climate, and management appear to be the same in the two areas that have different vegetation. How do we determine the causes of that kind of difference?

   Before we try to determine cause-and-effect relationships, we will consider a method of measuring and expressing differences in the vegetation of a prairie and a pasture (or a burned-over prairie and an unburned one, a prairie and the understory of a forest, or a well-groomed lawn and an abandoned lot). Because precise and complete measurement is extremely difficult and time consuming, we will make an estimate of canopy coverage by different kinds of plants in each of a number of small plots using a method described by R. F. Daubenmire (1959).

2. In data collection on each of the two sites, it is necessary to locate small plots for sampling. To avoid the influence of unconscious bias on the outcome of this survey, it is important to devise a system that determines locations of plots randomly. One method of determining plot placement is to cut numbers from an old calendar, placing them into a paper bag or some other vessel. The numbers are thoroughly mixed. For each plot, two numbers are drawn. The first number indicates how many steps to move in a certain direction from a given point, e.g., a corner fencepost, a stake, a tree. After mixing all the numbers again, the second number is drawn. The second number indicates how many steps to move either to the right or left at a right angle to the first direction. In fenced areas, the basic unit of distance might be the post-to-post distance. You may wish to devise your own system of random sampling.

   If vegetation is patchy, representative data may be obtained by greatly increasing the number of sample plots or by controlling the number of plots falling in different homogeneous vegetation units through systematic rather than random sampling.

   During the next few days we will visit the two study areas, learn to recognize the main plants in them, analyze the two areas by the canopy-coverage technique, and analyze the differences, searching for possible causes for these differences.

3. A rectangular wire frame is placed at a randomly determined location. Looking down at the frame, an estimate is made of the percentage of the framed area covered by the outline of the plants of a single species. A class number representing that percentage is recorded on the data sheet. The class numbering scheme is printed at the right of this page and at the top of each data sheet. This procedure is repeated for each species that forms any part of the canopy over the framed area. The frame is then moved on to the next randomly determined location and the procedure is repeated for each species that covers the framed area.

Coverage Classes

Percentage Coverage	Class Number
0 - 5%	1
5 - 25	2
25 - 50	3
50 - 75	4
75 - 95	5
95 - 100	6

The data sheet is organized like this:

Species Name	Class Number for Plot . . .									
	1	2	3	4	5	6	7	8	9	10
A. Big Bluestem	6	5	1	3	6	6	6	5	6	3
B. Sage	3	1	3	3		1		1		1
C. Unidentified grass	2	4	4	4	1		2			1
Etc.										

If you are unable to recognize a species, ask the teacher for the identification or take a sample, attach to it a piece of masking tape with a letter you assign to that species, and identify it later if it is present in significant quantity. See the above table for an unknown grass which may be labeled "C".

Part II. Data analysis

Distribute copies of the Canopy-Coverage Analysis Calculations Sheet (Supplement #2) to each group of students for analysis of data. For each species, the number of plots in each class (representing a percentage of coverage) is multiplied by the midpoint of that class. The sum of these products is divided by the total number of plots to produce the average percentage of coverage of the vegetated area by that species, e.g.:

Species	Class Number	No. of Plots in This Class	Mid-Point	No. of Plots X Midpoint	Total No. of Plots	Average Coverage %
Big Bluestem	1	1	2.5%	2.5%		
	2	0	15.0	0		
	3	2	37.5	75.0		
	4	0	62.5	0.0		
	5	2	85.0	170.0		
	6	5	97.5	487.5		
				735.0	÷ 10	= 74%

Finally, have each group prepare a summary of the percentage coverages by various species and compare these values for each species in the two areas studied in a table such as the following:

Species	Average Percentage of Canopy-Coverage	
	Prairie	Pasture
Big Bluestem Little Bluestem Indian Grass Tripleawn Grass Lead Plant Giant Ragweed Etc.		

Part III. Data interpretation

Briefly summarize for the students the legal, climatic, and use descriptions of the study areas. Distribute the following questions to each group of students and ask them to work as a team in preparing thoughtful answers to them.

1. Tell why it is important to use a system of random sampling to determine placement of sample plots.

2. Describe the system of random sampling you used.

3. Explain why the system of random sampling you used was really random.

4. Tell why there are variations among different teams in the canopy-coverage for the same species of plant in the same area.

5. Tell how the differences in results among teams could have been reduced, thus making your results more reliable.

6. Determine possible reasons for differences in population density in the two study areas for several individual species. Consider their growth requirements, growth habits, and palatability to livestock. Use direct observation and library references to arrive at your tentative hypotheses.

7. Propose experiments that might confirm or nullify your hypotheses. You might want to perform one of these experiments.

8. Which area had the greatest variety (number of species)? Which area had the largest number of common species (species with total average coverage of 10 per cent or more)? This would be a measure of equitability. If the differences are very great, can you give any reasons for them?

9. Using the USDA Soil Conservation Service Range Condition Guides, classify some of the species that you found as decreasers, increasers, or invaders. In which area where there more decreasers? more increasers? more invaders? Can you explain this?

When all groups have completed their work, share answers during a class discussion.

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Module 23: Supplement #1

Canopy-Coverage Analysis Data Sheet

Area____________________

____

Date____________________

Coverage Classes

Percentage Coverage	Class Number
0 - 5%	1
5 - 25	2
25 - 50	3
50 - 75	4
75 - 95	5
95 - 100	6

Student Names:

____

____

____

____

Species Name	Class Number for Plot . . .									
	1	2	3	4	5	6	7	8	9	10
A.										
B.										
C.										
D.										
E.										
F.										
G.										
H.										
I.										
J.										
K.										
L.										
M.										
N.										
O.										
P.										
Q.										
R.										
S.										
T.										
U.										
V.										

Module 23: Supplement #2

Canopy-Coverage Analysis Calculations

Area________________ Student Names________________ ________________

Date________________ ________________ ________________

Species	Class Number	No. of Plots in This Class	Mid-point %	No. of Plots X Midpoint	Total No. of Plots	Average Coverage %
	1	______	X 2.5 =	______%		
	2	______	X 15.0 =	______%		
	3	______	X 37.5 =	______%		
	4	______	X 62.5 =	______%		
	5	______	X 85.0 =	______%		
	6	______	X 97.5 =	______%		
				______% (sum)	÷ ___	= ______%
	1	______	X 2.5 =	______%		
	2	______	X 15.0 =	______%		
	3	______	X 37.5 =	______%		
	4	______	X 62.5 =	______%		
	5	______	X 85.0 =	______%		
	6	______	X 97.5 =	______%		
				______% (sum)	÷ ___	= ______%
	1	______	X 2.5 =	______%		
	2	______	X 15.0 =	______%		
	3	______	X 37.5 =	______%		
	4	______	X 62.5 =	______%		
	5	______	X 85.0 =	______%		
	6	______	X 97.5 =	______%		
				______% (sum)	÷ ___	= ______%
	1	______	X 2.5 =	______%		
	2	______	X 15.0 =	______%		
	3	______	X 37.5 =	______%		
	4	______	X 62.5 =	______%		
	5	______	X 85.0 =	______%		
	6	______	X 97.5 =	______%		
				______% (sum)	÷ ___	= ______%
	1	______	X 2.5 =	______%		
	2	______	X 15.0 =	______%		
	3	______	X 37.5 =	______%		
	4	______	X 62.5 =	______%		
	5	______	X 85.0 =	______%		
	6	______	X 97.5 =	______%		
				______% (sum)	÷ ___	= ______%

Dwight Platt

Module 24: What's on my plot?

Age level: Lower elementary (Procedure A)
Upper elementary and junior high (Procedure B)

Subject: Biology **Theme:** Diversity

Sequence: Field trip **Prerequisites:** Module 1; Module 11 would be useful for older students

Objectives: To explore the variety of plants and animals to be found on a small study plot in prairie; for older students, to compare the variety of plants and animals in study plots in a natural prairie and in a grassland intensively managed by man

Best season: April to November

Time required: 30 to 45 minutes on Sand Prairie Natural History Reservation; Procedure B requires a similar time in a managed grassland; at least 30 minutes in the classroom to discuss the results

Materials required:
Rectangular wire frames, 100 cm. X 25 cm. (can be made from No. 9 wire, bent and taped together at the ends) - one for each group of students

Investigation

Procedure A (for lower elementary students):

1. A short study of the prairie before the field trip will make the study of the sample plot more interesting. Two resources are May (1972) and the article, "Life on the prairie," in Ranger Rick's Nature Magazine.

2. Ask the class if they would like to visit a prairie to see some of the prairie plants and animals. Tell them of the plans for a field trip to search a small sample plot of prairie for plants and small animals. Ask what they think they will find. Make a list on the chalkboard. For older students, decide on a list of general categories that they will look for--grasses, non-grasses (there is no good popular term for the non-grassy plants; you can introduce the term "forbs," or you can agree on some other name that the class suggests), grasshoppers, crickets, beetles, etc. Be sure that the students can recognize plants and animals that belong to the categories they have suggested and that they realize that there are many kinds in each of these categories.

3. When you arrive at Sand Prairie Reservation, divide the class into small groups (or you can have each student work independently if the class is small). Give each group one of the wire rectangles. Let each group pick the plot of prairie they want to study and lay the

wire rectangle on the ground to form the boundaries. Now ask them to observe the plot closely and find the plants and animals that live on their plot. For young students, have them tell the rest of the class each time they find something new on their plots, and you can keep a list. However, for older students, have each group keep a list based on the categories that they had earlier suggested. Have them list the numbers of different kinds of plants or animals of each category that they find. Help them to look for characters by which they can recognize the different kinds. If they find an animal that does not fit into any of the categories that the class had suggested, they will have to add a new category. You can have them make a very general category like "other insects" if you are not sure of the identification of some insects found.

4. In the classroom after the field trip, discuss what was found in the small samples of prairie. Point out that not everything that lives on this plot was found and that our plots were so small that large animals would not be found in them. But all of these animals and plants live together and make it possible for each other to live. Ask the students to draw a picture based on their experience in the prairie or to write a paragraph about one of the animals living in this prairie.

Procedure B (for upper elementary and junior high students):

1. Ask the class what kind of plant and animal community lived in this place before the European settlers came. How has this community been changed? The prairie is a grassland and there are still grasslands here today. How does a natural prairie differ from the grasslands that are found here today? Suggest comparisons with cultivated grasslands, such as lawns and wheat fields, if they are not mentioned. Discuss these questions briefly but do not arrive at any answers.

2. The dominant plants in a prairie are grass. Ask the class if all grass is the same or if there are different kinds of grasses. How do different kinds of grass differ? Ask the class what other living things might be found in a prairie. Introduce the term "forbs" if they are not familiar with it. List on the chalkboard the general categories of plants and animals that they name. Tell the class that you are arranging for a field trip so that they can investigate the variety of different kinds of plants and animals in a prairie and in a managed grassland.

3. After arriving at Sand Prairie Reservation, divide the class into small groups of 2 to 4 students, and give each group one of the wire rectangles. Let them find a piece of prairie they wish to study and lay the wire rectangles on the ground to form the boundaries of a study plot. Ask them to examine this plot and record the number of kinds of living organisms they find. They will not be able to name most of the species of animals or plants they find, but this is not necessary. They can use general categories like those they had listed on the chalkboard, but they should then determine the number of dif-

ferent kinds of each (number of kinds of grasses, number of kinds of grasshoppers, etc.). You should circulate among the groups and help them in looking for differences and similarities to determine the number of different kinds.

4. After the study of the sample plot in the prairie, take the class to a grassland that is maintained by human management practices and repeat the procedures there. Pick an area like a lawn or a grain field that is intensively managed.

5. Back in the classroom, compare the data. Have each group report on the variety of organisms found in each of their two plots. They should indicate the general categories they used and the number of different kinds in each category for each sample plot. Tabulate the reports on the chalkboard. Discuss the results, using some of the following questions:

   a. Which of the two areas had the greatest variety of different kinds?

   b. What management practices are used on the two areas? Is outside energy expended in these management practices?

   c. Is the difference in variety related to the management practices?

   d. If human management of the land ceased in this region of Kansas, which of the two areas that were studied would undergo more change? Which would remain more stable? What type of changes do you think would occur?

Summarize for the class the data reported on a prairie and a millet field in Odum (1975, pp. 48 and 52). Is the class data similar to that reported by Odum? Point out that farmers use energy necessarily to maintain simplified agricultural grasslands so that they can be harvested for products that we need. The natural prairie produces products that many other kinds of animals and plants need. The natural prairie has more variety or diversity of animals and plants that are adapted to each other, and this gives it more stability.

Statement of Concepts

A natural prairie is a diverse grassland in which many different kinds of plants grow. Grasses of many kinds are typical, but there are also forbs (broad-leafed, non-woody plants), and even some shrubs and trees. In this grassland live many different kinds of animals. Each of these plants and animals is able to find a niche in which it can satisfy its needs in the prairie. Many kinds can even be found on a very small sample plot of the prairie.

Man has replaced most of the prairie with managed grasslands. The objective of most management is to simplify the ecosystem so most of the production goes into products that man can harvest and use. This management usually involves an input of large amounts of energy in the form of cultivation, use of farm chemicals, fencing, etc. to maintain the simplified system. Without this energy input the agricultural system is very unstable. The natural prairie with more diversity is more stable.

References

1. Anonymous. 1974. Life on the prairie. Ranger Rick's Nature Magazine, vol. 8, no. 2, pp. 17-22 (February).

2. May, Julian. 1972. The Prairie Has an Endless Sky. Mankato, Minnesota: Creative Educational Society.

3. Odum, Eugene P. 1975. Ecology (2nd edition). New York: Holt, Rinehart and Winston, pp. 45-56.

Dwight Platt

Module 25: Detective work in a prairie

Age level: Elementary and junior high

Subject: Biology **Theme:** Interdependence

Sequence: Field trip **Prerequisites:** Modules 5 (or 6) and 11

Objectives: To explore a prairie to discover interdependent relations; to become observant of animal sign and what it can tell

Best season: Any season

Time required: At the discretion of the teacher

Materials required:
Film (optional): "Grassland Ecology" by Centron Films

Investigation

1. After the preliminary module on interdependence (Module 5 or 6), discuss with the class the nature of interrelations between organisms in a prairie. "Who eats who" is an important set of interrelations, but there are many more. Examples can be found in the discussion by Allen (1967), or you may want to show the film, "Grassland Ecology," and look for interdependent relations.

2. After arriving at Sand Prairie Reservation, divide the class into small groups of 2 to 4 students. Show poison ivy to the class and warn them to avoid it. Ask each group to investigate the prairie and find evidence of interdependent relations between organisms. Discuss the type of evidence they are to find so that they will know what to do. Evidence may be direct--a shrub supporting a lichen or a vine, a hawk observed catching a rabbit, a goldfinch observed taking thistledown for its nest, etc. Evidence may be indirect--only a clue to what has happened, often called animal sign--a plum bush that has been girdled by a cottontail, a bird dropping that contains pokeberry seeds, a nest with an outside covering of spider silk, etc. Animal sign that simply indicates that an animal has been there (for example, a set of tracks) is not to be included. There must be evidence of a relationship between two different species. At least one of the species involved should be identifiable, but both need not be. The book by Murie (1975) can be used to identify some of the animal sign.

3. Each student should record information in a notebook about one example of each interrelationship for which his/her group finds evidence. The information should include:
    a. The nature of the interrelation
    b. The species involved (you should be available to help with identification when needed)
    c. A description of the evidence.

4. When the students gather together after the investigation, see if any groups still need help with identifying anything they have observed. When all have completed their records, have the groups report. Ask group 1 to report one interrelation they found. Ask how many other groups found evidence of the same relation. Then ask group 2 to report another relation. Continue in this way until the groups have reported on all the relationships recorded. You should keep a list of the relationships reported.

5. Pick out examples from those reported that illustrate various types of interrelationships and discuss them with the students the next day in the classroom. Ask how important the relationship is to each species and how each species is affected. After discussing a number of examples, discuss the following question: Do you think the animals and plants that live on Sand Prairie Reservation are a chance collection of species that happened to get there, or is it the group that can survive there because the species depend on each other for necessities of survival?

Statement of Concepts

See Statement of Concepts in Module 5 or Module 6.

Many animals are secretive and difficult to observe. However, they often leave clues to their activity, like tracks, diggings, scats, etc. These are known as animal sign.

References

1. Allen, Durward L. 1967. The Life of Prairies and Plains. New York: McGraw-Hill, pp. 74-167.

2. Murie, Olaus J. 1975. A Field Guide to Animal Tracks (2nd edition). Boston: Houghton Mifflin.

Dwight Platt

Module 26: A clue chart for grasses

Age level: High school (Procedure A)
Upper elementary and junior high (Procedure B)

Subject: Biology **Theme:** Diversity

Sequence: Field trip **Prerequisites:** Modules 1 and 11

Objectives: To recognize the diversity of grasses in a prairie; to learn some of the parts of a grass plant and to become observant of details of structure; to understand some of the adaptations of grasses for the prairie environment

Best season: Mid-May to October

Time required: ½ to 1 hour in class before the field trip; 1 to 1½ hours on Sand Prairie Reservation; at least 1 hour in the classroom after the field trip

Materials required:
Slide set #11: "Characters of Grasses" (available on loan from SKEEC)
Hand lenses - one per student or per 2 students
Spade
Buckets

Activities

Trying to identify grasses can be a frustrating experience for the beginner. On the other hand, a clue chart can be used to sharpen a student's observations, teach him/her something about a grass plant and give him/her an experience with the diversity of grasses in a prairie.

Before beginning this activity, the teacher should obtain sufficient background by looking at some of the references and consulting with SKEEC personnel that he/she understands those structural features of the grass plant that he/she will include in this study. A very short time with SKEEC personnel examining a grass plant is all that is necessary to give a teacher with limited background sufficient understanding to lead this activity.

Procedure A (for high school or advanced junior high students):

1. Distribute to each student or each 2 students a grass plant complete with roots. Ask the class: What are grasses? How do you recognize a grass? List the characters suggested by the class on the chalkboard. You should suggest some of the following if they are not mentioned, but give the class a chance to suggest them first:

   a. The leaf is composed of a basal sheath surrounding the stem and an expanded blade.
   b. The leaf blade has parallel veins.
   c. The leaf blade is usually rather long and narrow (strap-shaped).

d. The stem is divided into nodes (or joints) and internodes.
e. Growth of the stem takes place at the base of the internodes. If the tip is cut off, the grass stem can continue to grow.
f. The stem is usually hollow, although the nodes are solid.
g. Grass plants are non-woody (bamboos are an exception) and the above-ground parts die back each year; perennial grasses grow again from underground buds.
h. The roots are usually fine and fibrous.
i. Grasses have flowers, but the flowers have no petals.

Information on grass plant structure can be found in Gates (1937, pp. 40-45, 70) and Pasture and Range Plants, p. X.

Point out to the class that grasses are one of the largest groups of plants and that there are many different kinds of grasses. Suggest that the class visit a prairie to observe some of the differences in grasses.

2. Before the field trip, prepare a clue chart and duplicate copies for students. You can select characters from the sample clue chart (Supplement #1). Include a couple of blank rows at the bottom of the clue chart for other types of characteristics students might decide to record. The clue chart will give more or less structure to the students' observations depending upon the categories of characters included. While constructing the clue chart, keep in mind your objectives in using the exercise, and the background and interest of your class. For younger students, use fewer categories and those that can be observed most easily.

   If you have included some technical terms on the clue chart, assign some students to find out their meaning. You should refer them to references (see References) and then suggest that they examine a grass plant to find the structure. When students report to the class on these characteristics of the structure of grasses, you can use the slide set, "Characters of Grasses," to illustrate the structure being reported on.

   Prepare and duplicate a brief description sheet for the characters included on the clue chart you have prepared. You can adapt this from Supplement #2. You will want to simplify and abbreviate from these descriptions which were written to give sufficient background to the teacher. Some of the instructions can be given to the class orally and by demonstration.

3. When you arrive at Sand Prairie Reservation, find a grassland area with a number of kinds of grasses. Sit down and talk with the class about the purpose of this activity. Point out that each kind of plant has clues to its identity in its structure. The purpose of this investigation is not to name the various grasses but to look for clues that will tell which are different and how they differ.

4. Point out to the class that there are three different kinds of grass-like plants growing on Sand Prairie Reservation--grasses, sedges and rushes. Point out examples of these three groups of plants (sedges and grasses are widespread; rushes will have to be located; SKEEC personnel can help you in locating and identifying these three grass-like plants) and demonstrate the clues to the identity of each:

Grasses	Sedges	Rushes
a. Usually hollow or flattened stem with conspicuous nodes.	a. Usually pithy or solid cylindrical or 3-sided (triangular) stems with inconspicuous nodes.	a. Cylindrical stems with inconspicuous nodes.
b. Margins of the leaf sheath are free and overlapping.	b. Margins of the leaf sheath are fused together or closed.	b. Margins of the leaf sheath are free and open.
c. Leaves are 2-ranked (every other leaf is one above the other on the stem).	c. Leaves are 3-ranked (every third leaf is one above the other on the stem) or plant is leafless.	c. Plant often leafless or with basal leaves only; rarely leaves on stem; leaves are flat and grasslike or cylindrical.
d. Small flowers, each between 2 scale-like bracts; no petals or sepals; flowers in small spikelets.	d. Small flowers, each usually above 1 scale-like bract; no petals or sepals; flowers in small spikelets.	d. Small brown or green flowers with 3 scale-like petals and 3 scale-like sepals; flowers not in spikelets.

(See Supplement #2 for background on terms not explained in this listing). Emphasize that no one clue can be depended upon to distinguish these three types of plants. For example, grasses usually have hollow stems, but some grasses have solid stems. It is also true in recognizing the different kinds of grasses that a number of clues will usually be necessary.

5. Distribute to each student or to each 2 students hand lenses and a copy of the blank clue chart and instruction sheet. Go over the instruction sheet with the class and review the various characters included. Ask the students (they can work alone or in pairs) to choose a grass plant to examine and to record in the first blank column of the clue chart a description of the characters listed. Some characters may vary on different parts of the plant and they should record this variability. Encourage them to examine the plant carefully and see if they can find some other characteristics that might be recorded. These can be recorded in the blank rows at the bottom of the clue chart. After recording a description of one grass plant, have them continue examining others. Each plant should be checked to see if it is a kind they already have described on the clue chart. If not, they should fill out a new column on the clue chart with a description of its characters.

6. When they have completed all columns of the clue chart, ask them to examine a few more grass plants to see if they can recognize those kinds described on their clue chart.

7. Take back to the classroom a few stalks of each of the following grasses (where possible get one stalk with flowers or seeds and one that has not formed flowers): Sand Bluestem Andropogon hallii, Little Bluestem Andropogon scoparius, Switchgrass Panicum virgatum, Indian Grass Sorghastrum nutans, Prairie Cordgrass Spartina pectinata, and Sand Lovegrass Eragrostis trichodes. SKEEC personnel can help you with the iden-

tification of these grasses, if necessary. If SKEEC personnel have given permission and if it will be possible to transplant them on the schoolgrounds or keep them in the classroom for further studies, you can dig out two or three grass plants that a number of students have described on their clue charts and put them in buckets to take back to the classroom. Point out the dense fibrous roots and the rhizomes and underground buds (if present) as you dig them out.

8. Back in the classroom, place the descriptions of the six grasses (include only those characters from Supplement #3 that were included on the clue chart and that apply to the plant at this season) on the chalkboard. Have students check their clue charts and compare the descriptions to see if they have described any of these six grasses. Emphasize that agreement in one of the characters does not necessarily mean that they have the same kind of grass. But all individuals of a species are not necessarily identical in all characters.

   Then have the students examine the grass stalks that have been brought back to see if they can identify them from the descriptions.

   If it is permissible, the students should transplant the grasses from the buckets to a corner of the schoolyard and water them until they are established. As the season progresses, the students can observe them and determine which of the characters they described on the clue charts change and which remain constant.

9. Three important features of the original prairie were large and small grazing animals, periodic drought, and prairie fires. Have the class list ways in which grasses are adapted to survive the effects of these factors (see Statement of Concepts). This discussion may lead to another period of observation of a grass plant to examine some of these adaptations more closely or to experiments such as those described in Module 33.

   Discuss the diversity of grasses in a prairie. Point out that 54 different kinds of grasses, 25 different kinds of sedges, and 5 different kinds of rushes grow on Sand Prairie Reservation. What is the importance of a diversity of grasses to a prairie community? (See Statement of Concepts).

Procedure B (for upper elementary and junior high students):

Follow Procedure A with the following modifications. Do no. 1, but limit the characteristics discussed to those easily observed by the students on the grass plant.

The clue charts and instruction sheets (no. 2) should be simplified for the age level of your class. The clue chart should have a relatively few characters chosen from the more easily observable ones. Color and height can be included, but do not put much stress on them as they are often variable within the same species of grass.

Do nos. 3, 5, and 6. Omit no. 4. Replace nos. 7, 8, and 9 with the following procedure: SKEEC personnel will indicate where you can dig out two or three plants. Have the students help you dig them out and put them in buckets to take back to the classroom. Point out the dense fibrous roots for absorbing water from the soil. (If you cannot transplant these grass plants, you may want to take only a stalk of each grass. However, you should still uncover the roots of a grass plant so that the class can see their dense fibrous nature. Replace the soil after you have observed them).

When you get back to the classroom, label the grass plants that have been brought back. If you are not sure of the common names of these grasses, SKEEC personnel can help you. Have the students compare these plants with the descriptions on their clue charts to see if any of these are the same as some of the grasses examined in the field. Emphasize that agreement with one clue does not necessarily make them the same. If they find one that is the same, they can put the name of that grass at the top of the column on the clue chart. They should fill out a new clue chart with the characteristics of those plants they have not examined before. Discuss the characteristics of these grasses with the class to see if everyone can agree on the descriptions of characters.

If possible, plant these grasses in a corner of the schoolyard and keep them watered until they are established. The students should observe the plants periodically to see which characters change as the season progresses and which remain constant.

Have a short discussion with the class about grasses in the prairie. Point out that there are many kinds of grasses in a prairie and each grows best under specific prairie conditions and makes its own contribution to the prairie. You may want to read the articles by Heady (1971A, 1971B, 1971C) to the class.

Statement of Concepts

The prairie is a grassland and grasses have a number of features that adapt them for the prairie environment. Prairies grow in a climate of moderate to low rainfall and seasonal or irregular drought. The dense fibrous root system, that is more extensive below ground than the vegetation is above ground, is efficient in utilizing soil water.

The leaves of many grasses are modified to reduce loss of water by evaporation. They have a heavy protective cuticle over the surface and dead fiber layers around the water channels. The leaf is often grooved. The stomata, or openings to the inside tissues, are at the bottom of these grooves to protect them from rapid air currents that would carry away moisture. The stomata are usually all located on the upper side of the leaf. When moisture is low, the leaf loses moisture in such a way that it curls upward, thereby completely enclosing all the stomata to reduce evaporation even more. Most of the above leaf characters can only be seen with the aid of a microscope.

Since the buds and food storage tissue are underground, when a drought comes, the above-ground parts can dry out and even die. The perennial underground roots and buds can remain dormant until conditions again become favorable for growth.

Fires originally burned the prairie periodically. The grass plant, with its perennial parts and food storage underground, was little harmed by the fire and was ready to grow again after the fire.

The prairie community contains large numbers of grazing animals, large and small. Since growth takes place at the base of each internode of the grass stem and often at the base of the leaves, the stems and leaves can continue to grow even after they have been clipped off by grazing animals. Other plants have to form new branch stems when the stem is clipped, because growth takes place only at the stem tip.

Although all grasses share certain similar adaptations, in any prairie there are many kinds of grasses, each with its own special adaptations. There are cool season grasses, such as Western Wheatgrass and Canada Wild-rye, which grow most actively in spring and fall. And there are warm season grasses, such as the bluestems, Switchgrass, and Indian Grass which grow most actively during midsummer.

There are grasses that grow best in the lowlands, such as Big Bluestem, Indian Grass, and Switchgrass. And there are grasses that are found mainly on uplands, such as Little Bluestem and Sand Dropseed.

There are grasses with roots that grow very deep but spread very little in the surface soil, such as Switchgrass. The roots of others, such as Canada Wild-rye, do not grow deep but spread extensively in surface soil.

With this diversity of grasses, the prairie plant community can make most efficient use of its resources. Different grasses can grow under conditions to which they are best adapted and contribute their production at seasons and in locations where they can grow best.

References

For the teacher:

On the structure of grasses

1. Anonymous. 1963. Pasture and Range Plants. Bartlesville, Oklahoma: Phillips Petroleum Co.
2. Copple, R. F. and A. E. Aldous. 1932. The identification of certain native and naturalized grasses by their vegetative characters. Kansas State College Agricultural Experiment Station Technical Bulletin #32.
3. Gates, Frank C. 1937. Grasses in Kansas. Topeka, Kansas: Kansas State Board of Agriculture.
4. Hitchcock, A. S. and Agnes Chase. 1950. Manual of the Grasses of the United States (2nd edition). Washington: U.S. Department of Agriculture.

On the ecological characteristics of some grasses

1. Smith, Robert Leo. 1974. Ecology and Field Biology (2nd edition). New York: Harper and Row, pp. 552-556.
2. Weaver, J. E. 1954. North American Prairie. Lincoln, Nebraska: Johnsen Publishing Co.

For students (elementary and junior high):

1. Heady, Eleanor B. 1971A. The wonder of grass. Ranger Rick's Nature Magazine, vol. 5, no. 3, pp. 7-10 (March).
2. Heady, Eleanor B. 1971B. Grass feeds the animals (part two). Ranger Rick's Nature Magazine, vol. 5, no. 6, pp. 41-47 (July).
3. Heady, Eleanor B. 1971C. Grass conserves soil and water (part three). Ranger Rick's Nature Magazine, vol. 5, no. 8, pp. 44-47 (October).

Module 26: Supplement #1

Clue Chart for Grasses

To the teacher: The most easily observed characters are nos. 1, 2, 3, 6, 8, 10, 15, and 16 (but 15 and 16 are often variable); nos. 10, 11, 12, and 13 can only be determined during the flowering and seeding season; it is necessary to dig around the base of the plant to determine no. 14; nos. 3, 4, 5, 6, 8, and 9 are usually the best characters for identifying grasses when not flowering.

Characters	Description of Grasses		
1. Stem--branching			
2. Stem--X-sect. shape			
3. Sheath			
4. Collar			
5. Ligule			
6. Leaf blade--margin			
7. Leaf blade--shape			
8. Leaf blade			
9. Leaf blade--in bud			
10. Inflorescence			
11. Spikelets--no. of florets			
12. Spikelets--flattening			
13. Spikelets--awns			
14. Rhizomes or stolons			
15. Color			
16. Height			
17.			
18.			

Module 26: Supplement #2
Description of Characters in Grass Clue Chart

(Technical names are included in parentheses)

The stem (culm) of a grass plant is composed of nodes (evident as a ridge and/or groove which is differently colored) and internodes (the region between nodes).

1. Stem--branching. Some grasses branch only from the base or crown at the surface or underground. In others, branch stems may arise from some nodes of a stem above the base.

2. Stem--X-sec. shape. In cross-section, a stem may be round or flattened to various degrees.

3. Sheath. The leaf of a grass is composed of a sheath (a part surrounding the stem) and a leaf blade. The sheath attaches to the stem at a node and surrounds the stem above this node.

   a. The sheath is usually open on the side opposite the blade with free overlapping edges or margins. The margins of the sheath may be thin and papery, hairy, or unmodified.

   b. The sheath itself may be hairy or without hairs. The nature and pattern of the hairs may be an important character.

   Can you see other differences in the sheaths of different grasses?

4. Collar. The junction between the sheath and the blade is the collar.

   a. The outside of the collar may be without hairs, with hairs, or with hairs only on the margin. The nature and pattern of hairs on the collar may be an important clue.

   b. The collar may have auricles or projections on each side that extend all or part of the way around the stem.

5. Ligule. The ligule is a structure on the stem side of a leaf at the junction between the blade and the sheath that helps keep water and dirt out of the space between the sheath and the stem.

   a. It may be a membrane or band of hairs. The membrane may be thin and papery or may be thickened with teeth on either edge.

   b. The height of the ligule varies in different species.

6. Leaf blade--margin. The margin of the leaf blade may be smooth, have bristle-like teeth, have hairs, and/or have glands. Small firm teeth or bristles can often be felt with your finger along the edge better than they can be seen. Some of these structures may be restricted to the base of the blade.

7. Leaf blade--shape.

   a. The leaf blade may have different proportions of width to length.

   b. Cross-sections of the middle of the leaf blade may appear flat, convex upward, concave upward, curled at the edges, or folded and V-shaped. However, this may vary with the moisture content of the leaf, so it is unreliable after the leaf begins to dry.

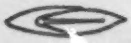
8. Leaf blade.

   a. The type and location of hairs on the leaf blade may be important.

   b. The midvein is prominent if it forms a distinct ridge on the lower surface of the leaf or is different in color. The number of large veins on either side of the midvein can be observed with a hand lens when the leaf is held up so that light shines through it.

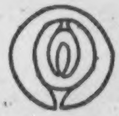
9. Leaf blade--in bud. The shape of a cross-section of the young leaf blade in the bud may be:

Fig.1.



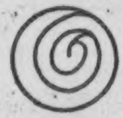
Flat

Fig 2:



Clasping

Fig.3.



Curled

If it is not possible to determine this by inspection, a cross-section can be made with a small scissors just below the ligule of the uppermost leaf.

The small flowers (florets) of a grass consist of a few stamens and a pistil located between a pair of scale-like bracts (lemma and palea). The florets attach directly (without a stem or pedicel) to the short axis or stem (rachilla) of a spikelet. At the base of the spikelet are 2 scale-like bracts (glumes) that are empty (without stamens or pistils).

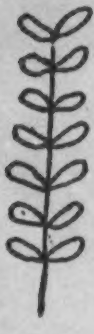
10. Inflorescence. The spikelets may be arranged in one of three types of inflorescences:

    a. Spike - spikelets arising directly from the main stem (rachis) of the inflorescence (not on pedicels). Example: Wheat.

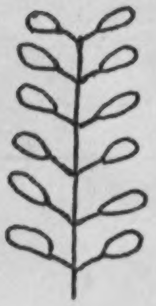
    b. Raceme (rare) - each spikelet on a pedicel arising from the main stem of the inflorescence. Example: Crab Grass.

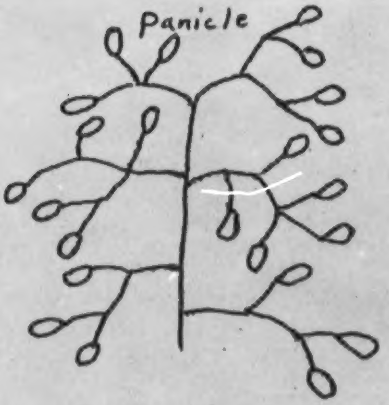
    c. Panicle - the pedicels arising from the main stem of the inflorescence branch a number of times and bear spikelets at the ends of these branches. Example: Oats.

Spike



Raceme

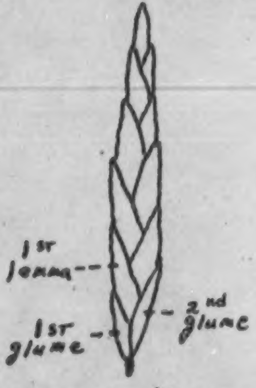




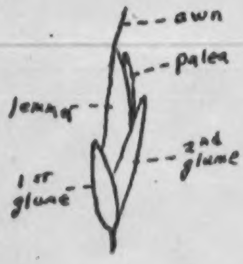
11. Spikelets--no. of florets. The number of fertile florets (those with stamens and/or pistils) in spikelets may vary from one to many.

12. Spikelets--flattening. The spikelets may be flattened laterally (from side to side) so that on the flattened side one can see the pairs of bracts coming together. Or the spikelets may be flattened top to bottom so one can only see the bracts of one side on the flattened side.

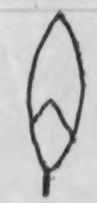
13. Spikelets--awns. The tips of some of the bracts in the spikelet may have bristle-like projections called awns, or there may be no awns.



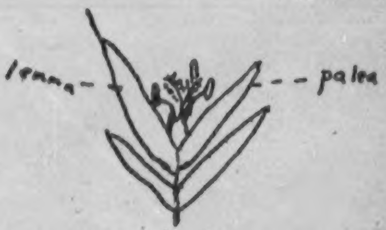
many-flowered spikelet



one-flowered spikelet (spikelet laterally flattened — looking at flat side)



one-flowered spikelet (spikelet flattened top to bottom — looking at flat side)



spikelet in flower

14. Rhizomes or stolons. The plant may spread by branch stems that creep along the surface of the ground or underground and give rise to new plants. These are stolons (above ground) or rhizomes (below ground).

15. Color. Grass plants may be various shades of green (esp. bluish-green) during the summer. This, of course, changes with season and the color may be somewhat variable among different individuals in the same species.

16. Height. Some grasses grow 6 to 8 feet tall when mature, while others rarely get above 6 inches. However, at different stages and under differing conditions, the height may vary.

Module 26: Supplement #3

Characteristics of Six Grasses Found Commonly on Sand Prairie Natural History Reservation

(The numbers refer to the characters in Supplement #2 and on the sample clue chart, Supplement #1)

A. Sand Bluestem Andropogon hallii (similar to Big Bluestem Andropogon gerardi in most features)

1) branches at base and a number of flowering stems arise at upper nodes. 2) round. 3) sheath is hairy on younger non-flowering stems but may have few hairs on older flowering stems. 4) long hairs on collar of lower leaves but may be no hairs on collar of upper leaves of flowering stems. 5) ligule is collar-like membrane (1 to 1.5 mm. high) sometimes almost hidden in tuft of hairs. 6) with bristle-like teeth pointed toward tip. 7) flat to concave; strap-shaped. 8) young leaf has long hairs on upper surface at base but no hairs on old leaf; midvein prominent; 4 large veins (and 1 smaller vein near midvein) on each side of midvein. 9) curled. 10) 3 (2 to 4) spike-like racemes on tip of stem. 11) 1. 12) flattened top to bottom. 13) awns present. 14) rhizomes present. 15) light green with some areas bluish, whitish, or purplish. 16) maximum 8 feet.

B. Little Bluestem Andropogon scoparius

1) branches at base and a number of flowering stems arise at upper nodes. 2) flattened. 3) margin papery; base pinkish. 4) usually without hairs. 5) membrane (1 mm. high) often coming to point in middle. 6) with bristle-like teeth pointing toward tip. 7) flat to V-shaped; strap-shaped. 8) no hairs or only a few near margin at base; midvein prominent; 3 (2 to 4) large veins on each side of midvein. 9) folded. 10) spike-like racemes at tip of stems. 11) 1. 12) flattened top to bottom. 13) awns present. 14) no rhizomes or stolons. 15) light green with bluish, pinkish, and purplish areas; reddish in fall. 16) maximum 3 to 4 feet.

C. Switchgrass Panicum virgatum

1) branches at base and uncommonly at the upper nodes. 2) round. 3) margin with hairs in young leaf but few hairs in old leaf; rest of sheath without hairs. 4) hairs only on margin. 5) band of hairs (3 to 5 mm. high). 6) bristle-like teeth pointing toward tip. 7) flat; strap-shaped. 8) hairy on upper surface near base; midvein prominent, appears white or pinkish white above; 3 (to 5) large veins on either side of midvein with 4 or 5 small veins between them. 9) curled. 10) large panicle. 11) 1. 12) flattened top to bottom. 13) no awns. 14) rhizomes present. 15) medium green; may or may not be bluish. 16) maximum 7 to 8 feet.

D. Indian Grass Sorghastrum nutans

1) branching only from base. 2) round. 3) papery margin; hairy when young but without hairs when mature. 4) without hairs. 5) long membrane (2 to 4 mm. high), 2-toothed (with thickened outside margins); pink to brown when young. 6) bristle-like teeth pointing toward tip. 7) flat becoming concave and V-shaped toward base; strap-shaped but tapers to a narrow base. 8) no hairs; midvein prominent, appears light above; indistinct large veins (3 to 6) on either side of midvein but many smaller ones. 9) curled. 10) 1 narrow dense panicle on stem. 11) 1. 12) flattened top to bottom. 13) awns present. 14) rhizomes present. 15) bluish green; stems often reddish. 16) maximum 7 to 8 feet.

E. Prairie Cordgrass Spartina pectinata

1) branching only from base. 2) round. 3) papery margin; no hairs. 4) hairs on margin. 5) band of hair (1 mm. high). 6) bristle-like teeth pointing toward tip. 7) flat to concave. 8) no hairs; midvein prominent; 4 to 5 strong veins on either side of midvein. 9) curled. 10) usually 10 to 20 one-sided spikes on each stem. 11) 1. 12) flattened laterally. 13) awns present. 14) rhizomes present. 15) dark green, never bluish. 16) maximum 8 to 9 feet.

F. Sand Lovegrass Eragrostis trichodes

1) branching only from base. 2) round. 3) no hairs or a few near top. 4) tuft of conspicuous white hairs on sides. 5) low brownish membrane (less than 0.5 mm. high). 6) small bristle-like teeth pointing toward tip. 7) flat. 8) no hair; midvein prominent; 5 to 6 large veins on either side of midvein. 9) curled. 10) large panicle. 11) 4 to 6. 12) flattened laterally. 13) no awns. 14) no rhizomes or stolons. 15) light green. 16) maximum 4 feet.

Dwight Platt

Module 27: Recycling in a prairie

Age level: Elementary grades

Subject: Biology **Theme:** Rhythms

Sequence: Field trip **Prerequisites:** Modules 7 and 11

Objectives: To understand that the soil is a community of organisms that recycle the waste products and dead bodies of plants and animals in the prairie; to learn about some of the organisms in this community; to realize that the cyclic use of matter is one of the natural rhythms in a prairie

Best season: September to November and April to June, or during the growing season whenever the soil and the plant litter are moist; parts of the activities can be done at any season

Time required: ½ hour in the classroom before the field trip; 45 minutes for the field trip on Sand Prairie Reservation; a minimum of 1½ hours in the classroom following the field trip

Materials required:
- Square wire frames, 60 cm. X 60 cm. (can be made from no. 9 wire, bent in a square and taped together at the ends) - one per group of students
- Small grass clipper or large scissors - one per group of students
- Paper or plastic bags - two large ones and three medium-sized ones per group of students
- Bucket - one per group of students
- Spade - one per group of students
- Hand lenses or low-powered microscopes (10 to 40X magnification) - one per 4 students, or one demonstration microscope
- Tullgren funnels (optional); (available on loan from SKEEC)

Activities

Part I.

Ask the class what "recycling" is. Ask them whether they have helped with any project to recycle paper, cans, etc. Encourage them to tell of their experiences. Make the point that recycling is using old waste objects or materials to make new and useful objects or materials.

Ask the class if recycling occurs in a prairie like the one they have studied (in Module 11). What becomes old and worn out in a prairie that can be recycled? Tell the class that you are planning a field trip to Sand Prairie Reservation where they can study recycling in a prairie.

Part II.

The activities on the field trip can be done by the whole class working with an adult leader. Or, if the class is larger than 20, it should be divided into two groups, each with an adult leader. (For older students, you can divide the class into groups of 4 students each and allow each group to work independently on the study with a study sheet that you prepare).

1. For a study area, select a tall grassland in one of the low areas on the reservation. Lay the wire frame on the ground to form the boundaries of a sample plot. Now let different students make the following collections from the sample plot:

    a. Clip the live green vegetation at ground level and put it in a large bag. Do not include dead stems or leaves.

    b. Clip the upright dead stems and leaves and put them in the second large bag. Add to this bag the surface layer of the litter or mulch that consists of long pieces of dead stems and leaves that are recognizable as such.

    c. Collect the rest of the litter or mulch from the surface of the soil (do not take any soil) and put it in a third bag.

    d. Take some of the surface soil and put it in a fourth bag.

    All bags should be labeled as the collections are made.

2. Now spend time looking for different kinds of mushrooms or puffballs. See how many different kinds you can find. Help the class to describe each kind and have one student record the descriptions. Collect one good specimen of one of the mushrooms or puffballs growing on the soil by digging up some of the soil and litter under it in one piece and putting it in a bucket. You may want to collect two or three other kinds, but do not dig up soil with them.

3. Go to a willow thicket to find a moist decaying log or branch. (Be careful to avoid poison ivy near willow thickets). Break off pieces of the decaying log and put them in a fifth bag. Label the bag.

4. Take your collections back to the classroom. The students should study them as soon as possible. Until you can use them, keep the collections moist and cool. Put them into a refrigerator if one is available.

Part III.

For younger students, you will want to simplify the following activities and omit some.

1. Study of a mushroom. Use Boles (1971) as a reference in helping the class study the mushrooms they collected. How many of the mushrooms that were collected were gilled mushrooms? How many of the kinds seen in the field were gilled mushrooms? Show the class the different parts of a gilled mushroom (see Boles, 1971, pp. 3-4). Did the class find any puffballs? Did they find any other kinds of fungi? What are fungi?

Talk about how mushrooms live. The mushroom is a structure for reproduction--to produce spores which can grow into new mushrooms. Help the class make a spore print with the cap from one of the mushrooms (see Boles, 1971, p. 14). The mushroom grows out of a fungus mycelium, a network of tiny whitish filaments or threads. These grow in an accumulation of moist dead material from plants or waste from animals or in soil rich in these materials. These tiny filaments cause the dead material to decay and they absorb some of the products of this decay in order to live and grow. In this process, they take many of the nutrients that are tied up in the old dead parts of plants or in animal waste and make it available for other plants to use in order to grow. So they contribute to recycling on the prairie.

Carefully dig around the mushroom that is in a bucket with a portion of litter and soil until you have exposed some of the mycelial filaments. Let the class examine these. Point out that this mycelium may continue to grow for years. It sends up mushrooms once in a while when conditions are right, and they last only a short time.

2. Study of decaying wood. Divide the class into small groups and have each group work on a table with a white top or on another white surface (white paper can be used to cover the surface). Give each group some of the decaying wood that was brought from the field. Ask them in what ways this decaying wood differs from live wood. What caused these changes? Have the students try to find any organisms that might have caused some of these changes. They may find some of the white filaments of a fungus. If possible, give each group of students a hand lens or low-power microscope. With this they may be able to see filaments penetrating many of the old cell spaces. Point out that the decay process takes apart old wood and makes the nutrients available for the growth of new plants. If any students find animals in their wood, identify them as specifically as possible (see Supplement #1).

3. Study of litter and soil from the grassland. Place the materials from bags 1, 2, and 3 collected in the grassland in separate piles on a table. How does the amount of decayed litter (bag 3) compare to the amount of undecayed litter (bag 2) and to the amount of green vegetation (bag 1)? The decayed litter is probably an accumulation from more than one year. Has the volume decreased in the process of decay? (The amount of green vegetation will increase from spring to fall, and your interpretation of this comparison will have to vary accordingly). If you are doing this investigation in the fall when the amount of green vegetation is a good measure of the year's production that will be contributed to the litter, and if you are working with older students, you may want to make a quantitative comparison. Take collections of each component of vegetation and litter from a sample plot to be dried so that the dry weights can be compared.

Give some of the green plant material (from bag 1) to each group of students. Also give each group some of the undecayed litter (from bag 2). Most of this litter is from last season's or this season's growth). Ask the class to compare the dead litter and the green plant material and to determine what changes have taken place in the dead material. List these changes on the chalkboard as they are suggested by students.

Give each group some of the decayed litter (from bag 3). Have them compare the two samples of litter. A hand lens or low-power microscope is useful in making this comparison. If you cannot provide these for each group, you may want to put some of the decayed litter under a microscope at the front of the room which the students can observe by turns. What changes have occurred in the decayed litter? List these changes on the chalkboard. What parts of the original green plant are still recognizable in the litter from the third bag? What parts have decayed most completely? Ask the students to sift through the litter to find organisms responsible for the decay. They may find filaments of fungi. Or they may find some animals. Help them identify these animals as specifically as you can and, if possible, determine their function in the soil community (see Supplement #1). Point out that many of the organisms responsible for decay are too small to be seen.

Give each group some of the top soil (from bag 4). Have the students examine it under a hand lens or low-power microscope (or have all the students look at the soil under a demonstration microscope). Is there material in this soil that probably came from decayed litter? Are any parts of the original plants still recognizable?

4 (optional). The animals in a sample of litter and soil can be collected with the use of a Tullgren funnel (available on loan from SKEEC). Identify these animals as specifically as you can (see Supplement #1). Put them on demonstration for the students with some information on their ecological function in the soil. Older students can help with identification and finding information. This information could be used as a basis for Module 35.

5. Discuss the nature of soil as a community of organisms. Point out that the soil community is a part of a larger prairie community. This soil community provides recycling of material for the prairie. For older students, you may want to discuss more detail of the organization of the soil community (for background material, see Smith, 1974, pp. 90-97, 539-547) and examples of matter cycles (Smith, 1974, pp. 119-122, 125-130).

Contrast the cycling of matter in the prairie ecosystem with the linear flow--from resource to user to waste dump--that is characteristic of so much human activity. Point out that the movement of matter in the ecosystem through repetitive similar cycles is one of the rhythms of nature.

Statement of Concepts

In any natural ecosystem, there must be capture of light energy and production of organic matter in photosynthesis. There must also be a continuous recycling of many chemical elements that must be used again and again in a finite system. In most ecosystems, these two functions are separated in different strata of the ecosystem. The basic organisms in the production strata above the soil are the green plants. The soil is usually the recycling stratum and the basic organisms are the decomposers. Many of these decomposers, such as yeasts, bacteria, or protozoa, are too small to be seen without high magnification. However, some decomposers, such as many molds, mushrooms, and other fungi, are large enough to be seen without magnification.

Decay is very similar to digestion. Many decomposers secrete digestive enzymes into the organic material in which they are growing and then absorb the products of digestive breakdown for their own nourishment. In this way, they break down the complex organic structure of dead plant or animal material and release many of the chemical elements for use by plants.

References

1. Allen, Durward L. 1967. The Life of Prairies and Plains. New York: McGraw-Hill, pp. 160-165.
2. Billington, Elizabeth T. 1971. Understanding Ecology. New York: Frederick Warne, pp. 20-25, 74-78.
3. Boles, Robert J. 1971. There's a fungus among us. The Kansas School Naturalist, vol. 18, no. 2 (December).
4. Smith, Robert Leo. 1974. Ecology and Field Biology (2nd edition). New York: Harper and Row, pp. 90-97, 119-122, 125-130, 539-547.

Module 27: Supplement #1

Some Common Animals Found in Litter and Soil on a Prairie

(An illustrated key available from SKEEC will provide help with identification. Magnification will be needed to identify some of these animals).

I. Worm-like animals without jointed legs.

1. Earthworms. The body is composed of more than 40 segments; head and tail end look very similar. (Earthworms eat soil and dead plant material or animal wastes and digest bacteria, fungi, protozoa, and some dead plant material. They are also important in fragmenting litter and mixing it with soil).

2. Insect larvae. The body is composed of fewer than 20 segments; the head end is often different from the tail end. (Some insect larvae living in the soil feed on plant roots; others eat dead organic matter, fungi, and bacteria; others may be predaceous on other animals).

3. Nematodes. The body is cylindrical but is not divided into segments. Nematodes are often abundant, but most are small and they are not commonly found by methods described in this module. (Some soil nematodes feed on plant roots; others on fungi and bacteria; others are predaceous on animals).

II. Soft, grayish unsegmented animals, usually with a shell.

1. Snails (with a shell) and slugs (without a shell). (Snails and slugs eat dead and living plant material).

III. Animals with jointed legs.

1. Animals with 7 or more pairs of legs.

   a. Pillbugs (Isopoda) - 7 pairs of legs and 1 pair of antennae; grayish and flattened segmented body; roll into a ball when disturbed. (Pillbugs eat dead and decaying organic matter).

   b. Animals with 15 or more pairs of legs.

      (1) Centipedes (Chilopoda) - 1 pair of legs on each body segment. (Centipedes are predaceous on other animals).

      (2) Millipedes (Diplopoda) - 2 pairs of legs on most body segments. (Millipedes eat dead organic matter and digest the fungi, bacteria, protozoa, and some dead plant material. They are also important in fragmenting dead organic matter).

2. Animals with 4 pairs of walking legs.

    a. Pseudoscorpions (Pseudoscorpionida) - small, less than 5 mm. long; 1 pair of appendages with large pincers in front of 4 pairs of walking legs. (Pseudoscorpions are predaceous on other small animals).

    b. Mites (Acarina) - small, less than 2 mm. long; body not divided into a front and back part by a narrow "waist" behind the legs. (Some mites feed on living plants; others eat fungi, bacteria, and plant litter; others are predaceous on other animals).

    c. Spiders (Araneida) - may be small or large; body divided into front and back part by a narrow "waist" behind the legs. (Spiders are predaceous on other animals).

3. Animals with 3 pairs of walking legs.

    a. Springtails (Collembola) - small wingless white or light-colored insects; with a forked "springing organ" on the lower side of the back of the abdomen. (Springtails eat fungi and decaying plant material).

    b. Bristletails (Thysanura) - small wingless insects with 2 or 3 long jointed tail-like cerci on end of the abdomen. (Bristletails eat fungi and decaying plant material).

    c. Ants (Hymenoptera) - usually darkish wingless insects with short antennae and large head; narrow waist between thorax and abdomen. (Ants nest in the ground but usually feed on materials collected above ground).

    d. Beetles (Coleoptera) - insects with wings, but front wings are modified as a hard wing cover covering abdomen (sometimes the wings are short and cover only the front part of the abdomen) with the 2 wing covers meeting in a straight line down the middle of the back. (Some beetles living in the soil eat fungi, spores, bacteria, and decaying plant material while others are predaceous on other animals).

    e. Insect larvae - worm-like wingless animals with 3 pairs of jointed legs near the front. (Insect larvae living in the soil may feed on plant roots, on dead plant material and fungi, or may be predaceous on other animals).

Dwight Platt

Module 28: Seasonal rhythms in a prairie

Age level: High school (can be adapted for junior high)

Subject: Biology **Theme:** Rhythms

Sequence: Field trip **Prerequisites:** Modules 8 and 11

Objectives: To study some seasonal changes on a small plot of prairie; to study the biological changes that occur and to see how these might better adapt prairie organisms and the prairie community for the seasonal changes in the physical environment

Best season: Two field trips; the second field trip should be at least 6 weeks after the first. The best timing to study annual seasonal changes would be a field trip in the spring followed by one in the summer and/or autumn. It can also be done with a field trip in autumn followed by one in the spring, a field trip in early autumn followed by one after frost, or a field trip in early spring followed by one in late spring. One of the field trips can be done in winter, but the differences may be too obvious and therefore of less interest to the students.

Time required: At least ½ hour in the classroom before the first field trip, two field trips of 1 to 1½ hours each on Sand Prairie Reservation, and 1 to 1½ hours in the classroom after both field trips have been completed

Materials required:

Mapping sheets (duplicated from Supplement #1) - at least six for each student or each group of 4 students

Quadrat frames (wooden frame 1 meter square divided by string into squares 20 cm. on a side) - one for each group of 4 students (one available on loan from SKEEC to serve as a pattern for constructing more)

Wooden stakes - four for each group of 4 students (each set of four should have a different number painted on the stakes)

Rulers - one for each group of 4 students

Investigation

1. Review with the class the nature of time-related biological rhythms as studied in Module 8. Discuss a procedure for studying seasonal rhythms in the prairie and let the class help plan an investigation. One method is a study of the same plot of prairie at two different seasons (see no. 7 for other possibilities). This module describes the procedure for such a study, but this procedure can be modified by the class. However, emphasize the importance of keeping accurate and complete records in the same way each time the plot is studied so that comparisons can be made.

Before the first field trip, duplicate copies of the mapping sheets (Supplement #1) so that you have at least six copies for each student or each 4 students (depending on whether you assign each student to keep a set of records or the group to keep one set of records). Each student (or each group of students) should have a notebook with a section for recording data from this study. The mapping sheets should be punched so they can be inserted in the notebook.

Consult with SKEEC personnel to select a mid-slope or upland prairie suitable for this study. If plant identifications are to be made, you and the students will need to become familiar with the common plants on this prairie (SKEEC personnel can provide help).

2. When the class arrives at Sand Prairie Reservation, divide into groups of 4 students each. Give each group a quadrat frame, a set of 4 stakes and 4 (or 16) copies of the mapping sheets. Each group should select a sample plot in the prairie to be studied and lay the quadrat frame on the ground to mark its boundaries. Each corner of the quadrat frame should be marked with a stake and the number on the stakes should be recorded in a notebook. The stakes should be firmly pounded into the ground as they will be used to locate the plot for later study. Mark the position of each sample plot on a map of Sand Prairie Reservation (available from SKEEC) and give one copy of this map to personnel at SKEEC so they can ensure that your plots are not disturbed by other studies.

3. In studying the plots, the students should be careful to disturb them as little as possible. The following information should be recorded from each sample plot:

   a. A list of the species of plants found on the sample plot. Each species may be identified if the teacher and students have become familiar with the common plants before the field trip. However, the investigation can be done without identification if, instead of a name, each different species found by a group is given a number and is described in their notebook well enough so that they can recognize it later. Sketches should be made of the leaves and of other parts that would provide useful clues to its identity. A small part of a plant can be collected (preferably from outside the sample plot) and pressed to help in recognizing that species later.

   b. The coverage of each widespread species should be mapped on one of the diagrams on a mapping sheet. Coverage refers to the total area within the plot covered by any part of the plants of a particular species when they are in the normal position in which they grow. Mapping can be done by drawing a line around the position of the peripheral parts of plants of the species on the diagram of the sample plot. Each diagram represents the square meter sample plot and the smaller squares represent the 20 cm. squares marked off with string. (A number of rare plants with limited and non-overlapping coverage can be mapped on one diagram). The location of the crown at the base of the plant should be noted on the diagram.

c. The periodicity stage of the species should be recorded. Periodicity categories might include:

dor. - dormant or dead; no live parts above ground

spt. - sprout or seedling; not more than 2 pairs of leaves expanded

veg. - with green foliage but no flower buds, flowers, nor seeds

f. bd. - flower buds present but no flowers

flw. - flowering

i. ft. - past flowering but fruits and seeds still immature

frt. - with mature seeds and fruits

d. The average height of plants of each species should be recorded.

When the students have completed recording all plants found on their sample plot, extra mapping sheets can be returned to you for use on the next field trip.

4. On the second field trip, each group should relocate the sample plot that they observed on the first trip. Procedures for observation and recording on the second trip should be the same as those used on the first trip. If identifications are not made, each species found on the second trip will need to be compared to the descriptions recorded on the first trip so that the same number is used for the species on both field trips (species not observed on the first field trip will be given new numbers). Location on the plot can also provide evidence of the identity of a species with one recorded on the first field trip. At the end of the last field trip, students should remove the stakes that mark the position of their plot.

5. Back in the classroom, each group should make comparisons of the data from the two field trips. Percentage of the sample plot covered can be found by determining how many of the 25 small squares are covered. They can summarize the information in a table of the following form:

Species	Field Trip 1 September 20, 1974			Field Trip 2 May 6, 1975		
	Periodicity	Average Height	Coverage (%age of Sample Plot)	Periodicity	Average Height	Coverage (%age of Sample Plot)
1	dor.	-	-	spt.	5 cm.	8%
2	frt.	1 m.	20%	veg.	30 cm.	16%
Etc.						

Those species observed on one field trip but not on the other should be listed "dor." in the season in which they were not observed.

If identifications of the species were made, the students may want to find information about the species observed. They can find out if they are annuals or perennials and therefore if there were dormant roots or only dormant seeds during the time when they were not observed.

6. Discuss the results of this study.

    a. What changes were noted in the plants observed on the sample plots? List these changes on the chalkboard. These changes may include: changes in life cycle stage of plants (periodicity); changes in height of plants (growth); replacement of some actively growing or reproducing species in one season by other actively growing or reproducing species in the other season.

    b. What are some advantages of these biological rhythms in the prairie? List suggestions on the chalkboard. These may include: plants can grow when conditions are best for them; some plants are growing at all seasons when plant growth is possible to make use of sunlight energy over the entire growing season; the flowering and fruiting of a plant can take place at a time which is most suitable--pollinators present, seeds most readily dispersed, etc.; varieties of food available to animals in community at all seasons; more species can utilize the same area if all are not active at the same time.

    c. In a simplified community, do the community functions vary more from season to season? Point out that in a wheat field the utilization of sunlight energy and active growth is high for a part of the season. However, while the field is fallow in the summer, little sunlight energy is being utilized in plant growth and little flowering or fruiting is occurring.

    d. If there were no seasonal changes in climatic or other physical factors, would there still be biological rhythms that varied with the time of the year? You can point out that a tropical rain forest with little change in climatic factors may still have seasonal biological rhythms, although they may not be as clear-cut as in a temperate prairie. Biological rhythms are a necessary pattern in the life cycle of most plants and animals.

7. Other methods of studying seasonal rhythms include:

    a. Phenology - a study of the timing of biological events. Students can keep records of the time of flowering of certain plants, time of arrival of certain migratory birds, time of breeding of frogs, etc. These records become more interesting if they can be continued over a number of years and compared.

    b. Life cycle of a particular species of plant or animal. Students can determine the timing of certain changes in the life cycle and note the way in which the life cycle is adapted to changes in the physical environment.

One of the above can be done in place of, or as a follow-up to, the study described.

Statement of Concepts

Seasonal rhythms in climate are a commonplace of experience to those of us who live in the temperate zones. These seasonal rhythms vary from place to place and may become almost non-existent in certain equatorial regions. They may involve primarily temperature (from summer to winter), or primarily rainfall (from wet season to dry season).

Biological rhythms occur in the life cycles of most plants and animals. The life cycle includes the stages in the life of an organism from embryonic to youth to maturity to senescence and death. It may involve such special stages as larvae or pupae or dormant seed. For those organisms that are long-lived, there may be shorter cycles of annual reproductive activity, dormancy, etc. Many of these biological rhythms are timed to run in synchronous fashion with the seasonal rhythms in the environment. This is one way of adapting the life cycle to the environment; for instance, dormant protected stages may coincide with the most adverse season in the environment.

Biological rhythms differ in different kinds of organisms. Some grasses and forbs are cool season plants, growing most actively in autumn and spring, and becoming quiescent during the hot summer as well as the winter. Others are warm season plants, with their maximum growth and reproduction during the warmer months of the year.

This results in a progression of biological change each year in a natural community. In the prairie different plants replace one another in growing, flowering, and producing seed; these different seasonal plant groups are called "aspects." There is the pre-vernal aspect in early spring when a few plants initiate the renewal of activity and growth. On Sand Prairie Reservation, a small violet, Johnny-jump-up *Viola rafinesquii*, is a common pre-vernal plant and it completes its growth and reproduction before the grasses grow to shade the ground. The vernal aspect, the profusion of spring flowering, follows. On Sand Prairie Reservation, some plants that bloom in the vernal aspect are Scribner Panicgrass *Panicum oligosanthes*, Ohio Spiderwort *Tradescantia ohiensis*, Serrateleaf Eveningprimrose *Oenothera serrulata*, Puccoon *Lithospermum caroliniense*, and Buckley Penstemon *Penstemon buckleyi*. The summer prairie is the estival aspect characterized on Sand Prairie by Fringeleaf Paspalum *Paspalum setaceum*, Silky Prairieclover *Petalostemon villosum*, Fourpoint Eveningprimrose *Oenothera rhombipetala*, various milkweeds *Asclepias* sp. and Yarrow *Achillea millefolium*. The autumnal aspect, the final activity in preparation for winter, is characterized by the blooming of Switchgrass *Panicum virgatum*, Indian Grass *Sorghastrum nutans*, the bluestems *Andropogon* sp., Roundhead Lespedeza *Lespedeza capitata*, Showy Partridgepea *Cassia fasciculata*, Camphorweed *Heterotheca subaxillaris*, the goldenrods *Solidago* sp., and the asters *Aster* sp. Dormancy of many of the prairie species typifies the heimal or winter aspect.

This type of differentiation in biological rhythms allows each species to become best adapted to the specific conditions to which it is exposed at the various stages of its life cycle. It allows more species to share a given plot of prairie as they "take turns," so to speak, in using the resources of the prairie plot. It also means that the prairie will be more efficient in the use of sunlight energy and other resources because in each of the aspects of the growing season there are plants well-adapted to make efficient use of these resources.

References

On seasonal rhythms in general:

1. Dice, Lee R. 1952. Natural Communities. Ann Arbor: University of Michigan Press, pp. 190-209.
2. Hanson, Herbert C. and Ethan D. Churchill. 1961. The Plant Community. New York: Reinhold Publishing Corp., pp. 85-90.
3. Odum, Eugene P. 1971. Fundamentals of Ecology (3rd edition). Philadelphia: W. B. Saunders, pp. 154-157.

On seasonal rhythms in the prairie:

1. Costello, David F. 1969. The Prairie World. New York: Thomas Y. Crowell, pp. 17-35.
2. Weaver, J. E. 1954. North American Prairie. Lincoln, Nebraska: Johnsen Publishing Co., pp. 9-10, 123-133.

Module 28: Supplement #1

Mapping Sheet

(Indicate direction of the arrow)

↑

Species ____________________

Periodicity ________________

Average Height _____________

Group ______________________

Date _______________________

↑

Species ____________________

Periodicity ________________

Average Height _____________

Group ______________________

Date _______________________

Robert Regier

Module 29: Discovering structural diversity

Age level: Junior high

Subject: Art **Theme:** Diversity

Sequence: Field trip **Prerequisite:** Module 9

Objective: To observe and record differences and similarities in natural structural patterns

Best season: Spring, summer, or fall; avoid weather too cold, wet, or windy to comfortably sketch and use the camera

Time required: At least 1 hour at Sand Prairie Reservation or other similar prairie environment

Materials required:

Sketch books or drawing paper firmly tacked, clipped, or taped to sturdy boards with a maximum size of 11" X 14"
Drawing pencils
Art gum, kneaded, or soft rubber erasers
Cameras (optional)
Tote bag or camera bag - one for each group leader
Magnifying glasses (optional)

Investigation

Design of the investigation. The class should be divided into groups of 5 to 10 students, depending on the number of adult leaders available. Each person in each group should be equipped for sketching. The leader of each group should have a tote bag for collecting small items, and a hand lens (optional). The groups should disperse over the reservation so that each group is responsible for a distinctly different area. Members of each group should stay within visual range of their leader. Those with cameras should be encouraged to have them available if they can be carried without hampering their ability to sketch.

Observing and recording. Each person should begin to locate natural forms that embody any of the five structural patterns described in Module 9. These are radial patterns, spiral patterns, modular patterns, branching patterns, and skeletal patterns. Some patterns will be much easier to find than others. Encourage each individual to look for several kinds. The three principal methods of recording the observations are by sketching, photography, and collection of smaller structures.

Sketching

It is important to observe carefully and draw the objects as accurately as possible. The entire form should be drawn just as it looks. The drawings should not be free interpretations or abstractions. It would be better to have two or three sketches carefully drawn than a dozen hasty sketches. No person should feel obligated to find examples of all the structures. They should only try to contribute a few well-made observations to the collective observations of the group.

Photography

Those with cameras will need to concentrate on larger forms unless they are equipped for close-up photography. It is important to isolate the specific form to be photographed from surrounding elements as well as possible. Every vantage point should be considered before a photograph of a specific form is taken.

Collecting

Some natural forms, such as flowers, seeds, seed pods, and other small items could be collected and brought back to the classroom for further observation and display. In doing this, take the opportunity to foster attitudes of respect for the natural environment by stressing careful selectivity and restraint. The leader of each group should be responsible for the collection of items so that carelessness and duplication can be avoided. No person in a group should pick or remove a form from its natural setting before checking with the leader.

Persons in each group could work quite independently. However, one might consider the value of assigning specific tasks to groups or individuals. These tasks could be defined in terms of the different structural patterns; i.e., certain individuals or groups could be assigned certain patterns, or the tasks could be assigned according to terrain, such as working in low areas bordering water or elevated areas.

As the groups make their observations, the leaders should remind them not to overlook structural patterns in very minute forms. A hand lens or reading glass could be available to aid in the careful inspection of small patterns.

<ins>Concluding the field trip</ins>. As the groups gather, they should be encouraged to compare and share results, though this will be done more systematically after the return to the classroom.

<ins>After the field trip</ins>. The results of the field trip should be shared in a systematic way. Display space should be found for the sketches and collected items. Later the photographs can be added to the display. The display should be organized according to the five structural patterns. Perhaps examples of all five will not have been found. If not, the display could be completed with pictures and objects collected in Module 9, Activity, Part II.

Encourage the class to study the display carefully so that each person is aware of the entire result and not only the results of their own investigation. Discussion of the display and reflections on the field trip could be a further step in helping to sharpen the awareness of structural diversity and similarity in nature.

The intent of the field trip is to help persons sharpen their perception of their visual world and to help develop an appreciation of their natural environment as a source for an infinite variety of visual patterns. The next module (Module 44) will provide the procedure for utilizing this heightened visual experience in creative activity.

Statement of Concepts

The definitions of diversity and structure given in Module 9 should be reviewed. The five different structural patterns described in Module 9 should be reviewed and memorized. Careful observation and conscientious recording of observations should be stressed in this module.

Robert Regier

Module 30: Seeing the rhythms of the prairie

Age level: Junior high

Subject: Art **Theme:** Rhythms

Sequence: Field trip **Prerequisite:** Module 10

Objective: To observe and record the variety of rhythmic patterns that can be found on the natural prairie

Best season: Spring, summer or fall; avoid weather too cold, wet, or windy to comfortably sketch and use the camera

Time required: At least 1 hour at Sand Prairie Reservation or other natural prairie environment

Materials required:

- Sketch books or drawing paper firmly tacked, clipped, or taped to sturdy boards with a maximum size of 11" X 14"
- Drawing pencils
- Art gum, kneaded, or soft rubber erasers
- Cameras (optional)
- Tote bag or camera bag - one for each group leader

Investigation

Design of the investigation. The class should be divided into groups of 5 to 10 students, depending on the number of adult leaders available. Each person in each group should be equipped for sketching. The leader of each group should have a tote bag or jacket with large pockets for collecting small items.

The groups could disperse over the reservation so that each group is responsible for a distinctly different area. However, wide dispersal may not be desirable if each leader is not familiar with the reservation. Members of each group should stay within visual range of their leader.

Observing and recording. Each person should begin to look at the landscape in terms of rhythmic patterns. It is important to alert them to the full scale range, from large patterns revealed in rows of trees, expanses of tall grasses, series of rolling sand dunes, etc., to intimate rhythms that might be found in a head of grass or the interior of a seed pod. Encourage each individual to look for both larger and smaller rhythms and for different kinds of rhythms. If repetitive, alternative, and progressive rhythms were discussed with the group prior to the field trip (Module 10, Supplement #1), these types might serve as a guide in their search. The three principal methods of recording the observations are by sketching, photography, and collection of smaller forms.

Sketching

It is important to observe carefully and draw the forms that illustrate a rhythm as accurately as possible. Such an approach will be sensitive to the irregularities and subtleties contained within a rhythm. The drawings should not be free interpretations or abstractions. It would be better to have two or three sketches carefully drawn than a dozen hasty sketches.

Photography

Those with cameras will need to concentrate on larger forms unless they are equipped for close-up photography. It is important to isolate the specific rhythm from surrounding elements as well as possible so that the photograph will clearly communicate the rhythm that was observed. Every vantage point should be considered before a photograph of a specific form is taken.

Collecting

Some small natural plant forms that illustrate rhythms, such as heads of grasses, seeds or seed pods, etc., could be collected and brought back to the classroom for further observation and display. In doing this, take the opportunity to foster attitudes of respect for the natural environment by stressing careful selectivity and restraint. The leader of each group should be responsible for the collection of items so that carelessness and duplication can be avoided. It would be better not to pick or remove a form from its natural setting before checking with the leader.

Concluding the field trip. As the groups gather, they should be encouraged to compare and share results, though this will be done more thoroughly after the return to the classroom.

After the field trip. The results of the field trip should be shared and displayed. Display space should be found for the sketches and collected items. Later the photographs can be added to the display. The display could be organized according to rhythmic types, though not all the rhythms found will necessarily fit the three types listed in Module 10.

Encourage the class to study the display carefully so that each person is aware of the entire result and not only the results of their own investigation. Discussion of the display and reflections on the field trip could be a further step in helping to sharpen the awareness of rhythm in our environment.

The next module (Module 45) will help the group utilize this heightened awareness of rhythm in creative activity.

Statement of Concepts

The discussion on the nature of rhythm in Module 10 should be reviewed. Only the visible rhythms of the prairie are pertinent for this investigation. However, an awareness of the broad range of rhythmic patterns present in the prairie landscape, both hidden and visible, is helpful. For examples of more hidden rhythms of the prairie, see Modules 7, 8, 14, and 28.

Emphasis should be placed not only on the prevalence of rhythmic patterns, but also on the variety these patterns exhibit. Concern for noting variety will help sharpen observation and encourage the group to be aware of subtle as well as obvious differences in visual rhythms.

The varied rhythmic patterns present in a prairie landscape is another illustration of the principle of variety within unity which was discussed in the Statement of Concepts in Module 9. The repetition present in rhythms produces unity. The differences in the arrangement of these repetitions provides variety.

Dwight Platt

Module 31: What causes rhythmic sleep movements in plants?

Age level: Upper elementary

Subject: Biology **Theme:** Rhythms

Sequence: Post-field trip **Following:** Module 14

Objectives: To learn more about the nature of biological rhythms; to design and perform experiments to test a hypothesis

Time required: A minimum of two ½-hour discussion sessions before the experiment and 1 hour to plant seeds and set up the initial experiment. Two ½-hour sessions will be needed to summarize observations and discuss the results. Further experimentation can be done as desired.

Materials required:

Tin cans or small plastic containers in which to plant seeds - one for each child or for every 2 children, as desired
Bean seeds
5 pepperwort ferns *Marsilea mucronata* (available on loan from SKEEC)

Investigation

1. Review with the class the observations made on your field trip to Sand Prairie Reservation. Remind them of the "sleep movements" of the leaves of some of the plants.

2. *Make hypotheses*. Again discuss and let the class amplify hypotheses to explain the control of these rhythmic movements. Set up at least two alternative hypotheses:

   a. One hypothesis postulates an environmental control of the rhythm. What environmental rhythm might determine the rhythmic movement of the leaves? The rhythmic changes from light to dark during the 24 hours of a day would be an obvious possibility. The leaf movements may be simple responses to the changes of light.

   b. Another hypothesis postulates that the rhythmic movements were caused by rhythmic internal changes in the plant and were not direct responses to environmental changes. Point out to the students that they become sleepy at night even if the light is on in their rooms. Sleepiness is caused by an internal rhythm.

   These hypotheses are two possible explanations of the rhythmic sleep movements in plants.

   How can we decide between these two explanations (or any others the class might suggest)? Discuss this with the class. If a student does not suggest doing some experiments, you should point out that a scientist answers questions like this by performing an experiment.

3. Discuss the nature of an experiment. Stress the following:

   a. An experiment would involve the observation of a plant under two conditions, control conditions and experimental conditions.

   b. Control conditions might be set up to be similar to natural conditions.

   c. Experimental conditions would be the same as control conditions except that the one condition to be tested would be varied.

   d. The experiment should be planned so that the results expected if the hypothesis being tested is correct would be different from the results expected if the hypothesis is incorrect.

   e. Experimental observations should be repeated on many plants to see how reliable the results are.

   Suggest that the class perform an experiment to test the hypotheses postulated to explain rhythmic sleep movements in plants. Point out to the class that you have borrowed 5 pepperwort ferns like those observed on Sand Prairie Reservation for use in the experiment. Also suggest that the class test bean plants to see if they behave in the same way.

4. Now have the class plant bean seeds for the experiment in cans or plastic containers, 2 bean seeds in each container. Preferably each student should plant one container, although one container can be planted by each 2 children if the class is very large or space is limited. Be sure that drainage holes are made in the bottom of each container before the soil is put in it. The planted containers should be placed near a window but where they will be kept warm, with a tray or other shallow pan under them to catch drainage water. Responsibilities should be assigned to students for keeping the plants watered.

5. Design the experiment. On a later day, help the class to design the experiment to be used with the pepperwort ferns and the bean plants. Plants to be observed under control conditions can be placed in a window where they get sunlight but where they get little or no artificial light at night, so they have natural cycles of light and darkness. Observations should be planned for different times of the day to see if the leaves are outstretched or folded. If the experiment is designed as in "a" below, observations will only need to be made during classtime. Otherwise, arrangements will have to be made for observations at night as well. However, in any case, the bean plants can be taken home by students so that they can be observed a few times after dark to see that the leaves do have sleep movements.

   The experimental conditions can be designed by the class in a number of ways. They may want to try more than one set of experimental conditions. However, to keep the conditions as similar as possible, the same plants that are used for making the control observations should be observed under the experimental conditions. Also, observations to determine the position of the leaves under control conditions and under experimental conditions should be made at the same times of day and/or night. Some possible experimental designs are:

a. Place the plants in a dark closet or cabinet during the day when they would normally have light.

b. Place the plants under a bright light at night.

c. Place the plants in continuous artificial light for 24 hours a day.

d. Place the plants in continuous dark for 24 hours a day.

When the class has decided on experimental conditions, they should make predictions. How will the plants behave if hypothesis "a" is correct (see no. 2 for hypotheses)? if hypothesis "a" is incorrect? if hypothesis "b" is correct? if hypothesis "b" is incorrect? These two hypotheses are alternatives, so evidence that one is correct is evidence that the other is incorrect.

6. Doing the experiment. When the bean plants have developed two pairs of leaves, perform the experiment with both kinds of plants, making the control observations and the experimental observations. Record the results in a table on the chalkboard. Pool the results from all plants of the same kind so that you can see how reliable they are.

7. Discussing the results. Discuss the results of the experiment with the class. What has been learned about the nature of rhythmic sleep movements in plant leaves? Did the experiment provide evidence to make a decision between the two hypotheses? Point out that the results of the experiment allow for a decision to be made on the hypothesis that best explains sleep movements in each kind of plant. However, they have found from the experiment that the control of sleep movements is not the same in all plants and that both hypotheses are correct, one explaining sleep movements in the leaves of the pepperwort fern and one explaining sleep movements in bean leaves.

8. Further investigation. If desired, further questions can be asked and experiments designed to learn more about the nature of these rhythmic movements. Two possibilities are suggested below.

What part of the pepperwort fern responds to changes in light and darkness to cause the leaf movements? Hypotheses might be:

a. Each leaflet acts individually in sensing the light changes and moving.

b. The movement of a leaflet is due to a response of the entire plant which senses light changes and causes all leaflets to move.

An experiment can be designed which places a few leaflets in the dark by covering them with a small can and allows the rest of the plant to remain in the light.

Does the environmental cycle of light and dark affect the internal rhythm of the bean plant by timing it or are the rhythmic movements of bean leaves not at all affected by changes in the light-dark cycle? These two hypotheses can be tested by placing bean plants under a bright light at night and placing them in the dark during the day. After a few weeks, observe whether the timing of leaf movements in the bean plant has been reversed to correspond with the new light-dark cycle or has remained the same as it was in the natural light-dark cycle.

Statement of Concepts

Biological rhythms usually correspond with some physical rhythms in the environment. However, the biological rhythms may be controlled in various ways. In the pepperwort fern, sleep movements of the leaflets are direct responses to light changes. The leaves are folded when the plant is in the dark and are outstretched when the plant is in the light. If the plant is kept in continuous light, the leaves remain outstretched and if the plant is kept in the dark for 24 hours, the leaves remain folded.

In the bean plant, the sleep movements are regulated by an endogenous or internal biological rhythm. If the plant is placed in continuous light or dark for 24 hours, the leaves will remain outstretched during the hours that would normally be daylight and folded during the hours that would normally be dark. The biological rhythm remains even in the absence of an environmental rhythm. However, the biological rhythm is timed to be synchronous with the environmental rhythm so that if the timing of light and darkness is changed, the timing of leaf movements will gradually change to correspond.

Students should learn that a scientific hypothesis is simply a reasoned guess but that, in a scientific study, it is necessary to construct hypothetical explanations before evidence can be collected for or against them. An experiment is one of the most important methods that the scientist has of obtaining evidence so that he can decide which hypotheses to accept as explanations.

It is important that students learn the characteristics of a good experiment:

1. It must be designed to give evidence for deciding whether a hypothesis is correct or not. The results of the experiment should be predictably different if the hypothesis is correct or if it is incorrect. If two hypotheses are alternative explanations, both may be tested by one experiment as evidence for one hypothesis may be evidence against the other.
2. All conditions should be similar for both the control and the experimental situation except for the condition being tested; so that any differences in result will be due to changes in that condition.
3. The experiment must involve a number of organisms or be repeated so that one can judge the reliability of the results. No conclusions can be made on the basis of an experiment done once with one organism.
4. The conclusions based on the results of the experiment can only be assumed to apply to the kind of organism tested and under the conditions of the experiment. Further experiments should be done with other species and under other conditions to find out how widely applicable the conclusions are.

References

For the teacher:

1. Brown, Frank A., J. Woodland Hastings and John D. Palmer. 1970. The Biological Clock--Two Views. New York: Academic Press.
2. Smith, Robert Leo. 1974. Ecology and Field Biology (2nd edition). New York: Harper and Row, pp. 191-197.

Dwight Platt

Module 32: An experiment to determine what grasshoppers eat

Age level: High school

Subject: Biology **Theme:** Diversity

Sequence: Post-field trip **Following:** Module 19

Objectives: To demonstrate a diversity in food utilization by similar species from the prairie; to learn how to test hypotheses by experiment

Materials required:
Insect nets (available on loan from SKEEC)
Screen insect cages (few available on loan from SKEEC)

Investigation

1. After the investigation in Module 19 has been completed, have the class look at the data and select two or more species of grasshoppers for further investigation. These species should be ones that were common and, therefore, that will be easy to collect. Each species selected should have a different type of mandible and these mandibles should be typical of species feeding on either forbs, grasses, seeds, or other insects.

2. Hypotheses about the food habits of these species of grasshoppers can be made from the limited data collected in Module 19. From the nature of its mandibles, ask the class to state a hypothesis about the food preferences of each species of grasshopper selected.

3. Take another field trip with the whole class or with a few students to catch 10 to 15 live individuals of each of the species selected for the experiment. The individuals of each species should then be placed in separate cages with dry sand on the bottom. The cages should be placed where they will be dry and get some sunlight.

4. The class should now attempt to verify their hypotheses by designing and running experiments to test the food preferences of each species. Have the students place a measured amount of one kind of food in each cage and then examine it 24 hours later for evidence that some of it had been eaten. One day each cage can be supplied with grass, the next day with some selected forbs, with grass seed heads, smaller grasshoppers or crickets, etc. The plant material supplied should be fresh and green; it may have to be placed in a can with shallow water to keep it fresh when the weather is dry. Once you have found food that a particular species will eat, you may want to test new foods every other day, alternating with a day on which the grasshoppers are given a good supply of the acceptable food so that the state of hunger will be similar for each test. A scale can be devised for measuring the results of each experiment, such as:

a. The food is untouched.

b. Minimal chewing on food.

c. Moderate amount of chewing on food.

d. Most of the edible parts of the food have been eaten.

You may want to test each food more than once to determine the reliability of the results.

5. Some other experiments that can be used are:

   a. Testing a food that is little eaten before and after a period of food deprivation to see if the state of hunger affects the feeding on a food.

   b. Collect grasshoppers of one species and divide them into two groups (at least 15 in each group) placed in two different cages. Feed one group with a food that they readily eat and the other group with a food that is eaten but only minimally. Determine after a period of a few weeks if there is a difference in survival, growth, etc.

6. Discuss the results of these experiments:

   a. Do these results tend to support or disprove the hypotheses that were being tested?

   b. Do you feel more sure about statements concerning the food habits of these species of grasshoppers after running the experiments?

   c. Are there some weaknesses in the experiments? (Point out, if the class does not mention it, that the conditions of captivity may affect the feeding of the grasshoppers).

   d. Do grasshoppers have different food preferences and, therefore, different food niches?

   e. Are particular species of grasshoppers dependent on particular types of food resources?

   f. What would happen to the number of kinds of grasshoppers if some food resources were eliminated from a prairie?

   g. Why did we use 10 or 15 grasshoppers of each species rather than only one?

Statement of Concepts

See Module 19.

References

See Module 19.

Dwight Platt

Module 33: How do grasses survive in a prairie?

Age level: Upper elementary and junior high

Subject: Biology **Themes:** Diversity and interdependence

Sequence: Post-field trip **Following:** Modules 26, 23, or 11

Objectives: To demonstrate some ways in which the grass life form is adapted for the prairie; to learn that many of the diverse kinds of grasses in the prairie have similar adaptations; to learn that some of the characters of grasses better adapt them to live with prairie animals

Time required: The activities will be continued over a period of a few weeks to a few months, but the observation and discussion periods are short

Materials required:

Large pots or containers for plants (plastic containers can be used for nos. 1 and 2, but not for no. 3) - 4 containers for each section of the module that is to be used
Bean seeds
Scissors or grass clippers
Ruler
Straw or torn paper

Activities

Three features characteristic of the original prairie were grazing animals, periodic drought, and prairie fires. The activities in this module are to demonstrate some ways in which grasses are adapted for these features of the prairie environment. You may use one, two, or all three sections of this module.

The grasses to be observed in section no. 1 can be growing outdoors, grown from seed indoors, or dug out in the field and transplanted to a large container indoors. The grass plants for nos. 2 and 3 should be transplanted to large containers indoors at least one month before they will be used for these activities. Consult with SKEEC personnel to select grasses that will be suitable for this study or to obtain some grass seed. Plant bean seeds in pots a month before you wish to use them in the following activities.

1. How does the growth of grasses differ from that of forbs (other non-woody plants)? How does a plant grow after being clipped off by a grazing animal? Take two grass plants and two bean plants and have the students clip off some of the stems and leaves to a measured height. Record the lengths of these cut stems and leaves. After two weeks, again have the students measure the lengths of these stem and leaves to the cut end. Have the cut grass stems lengthened? Have the cut grass leaves lengthened? Have the cut bean stems or leaves lengthened?

Have any of the cut parts died? Discuss with the students the differences in growth between grasses and forbs. Let them point out the differences. Which of the plants would be best adapted to continue growth after being grazed?

2. Take two grass plants and two bean plants that are both in containers of similar size with moderately moist soil. Ask the students to describe or sketch the position and shape of the leaves. Particularly ask them to note whether the leaves are held out flat or whether they are curled or bent.

   Withhold water from the bean and grass plants which were examined. Each day have the students record the position and shape of the leaves. Which plants begin to show the effects of "drought" first? Do the leaves of bean and grass respond in the same way to lack of water? Which response would reduce evaporation most effectively? Point out that many of the stomata (openings through which leaves may lose water) are on the upper surface of grass leaves. The leaves of which plants died first from the lack of water?

3. Take two grass plants and two bean plants (growing in non-combustible containers) outside to a location where there is little or no wind and no combustible material nearby. Place 3 inches of dry straw or torn paper over the soil in the containers with grass plants and with bean plants. The soil should be rather dry. You should light the mulch of paper or straw and let it burn completely, also burning the plants. Keep the students away from the burning plants and have a bucket of water nearby to extinguish the fire, if necessary.

   After the burning is complete, pour water over the containers to cool them off before handling them. Place the containers where they will get warmth and light. Keep them well-watered. Have the students observe the burned plants for a number of days and record evidence of renewed growth. Where does this growth start? Which plants start to grow again readily after being burned?

   With older children, an experiment can be done by burning a small plot of grassland outdoors. However, this should be done with extreme caution because grass burns very rapidly and a fire can easily get out of control. Any area burned should be small and the area around the plot should be cleared of combustible material. Select two similar small plots of grassland, one to be burned and one to be undisturbed. Have the students examine the plots before burning and count the numbers of grass plants, forbs, and/or woody plants on each plot. After burning one plot, have the students examine the two plots periodically and make counts of the plants that are actively growing. Which plants grow back most rapidly after the fire? Has the fire caused any changes in the plant composition of the plot?

4. Discuss the results obtained from these demonstrations. Which of the two kinds of plants would be best adapted for grazing, drought, and fire? Which could better thrive in the prairie? Point out that there is a diversity of grasses in a prairie, but many of them are similar in their adaptations to the prairie environment. However, also point out that many forbs are well adapted for prairie conditions.

Statement of Concepts

The prairie is a grassland, and grasses have a number of features that adapt them for the prairie environment. The prairie community contains many grazing animals, large and small. Since growth takes place at the base of each internode of the grass stem (see Supplement #2 of Module 26 if you don't know what an internode is) and often at the base of the leaves, the stems and leaves can continue to grow after they have been clipped off by grazing animals. Other plants have to form new branch stems or new leaves when they are clipped because growth takes place only at the stem tip.

Prairies grow in a climate of moderate to low rainfall and seasonal or irregular drought. The leaves of many grasses are modified to reduce loss of water by evaporation. They have a heavy protective cuticle over the surface and dead fiber layers around the water channels in the leaf. The leaf is often grooved. The stomata, or openings to the inside tissues, are at the bottom of these grooves to protect them from rapid air currents that would carry away moisture. Many of the stomata are located on the upper surface of the leaf. When the soil is dry and evaporation high, the leaf loses moisture in such a way that it curls upward, thereby completely enclosing these stomata to further reduce evaporation.

Fires originally burned the prairie periodically. The grass plant, with perennial buds and food storage tissue underground, is little harmed by fire and is ready to grow again after the fire. Growth is often stimulated by the nutrients released by the fire. Some forbs will also become more abundant and vigorous after a prairie fire. However, the effect of fire on prairie grasses and forbs is dependent upon the season at which the fire occurs. The underground buds and food storage tissue of grasses are also an adaptation to drought. The above-ground parts can dry out and even die, but the perennial underground roots and buds can remain dormant until conditions again become favorable for growth.

Many kinds of grasses share the above prairie adaptations. However, some grasses may not have all of the above adaptations. Some grasses, for instance, are annuals without perennial underground parts. They reproduce each year from seed.

References

1. Smith, Robert Leo. 1974. Ecology and Field Biology (2nd edition). New York: Harper and Row, pp. 552-556.

2. Weaver, J. E. 1954. North American Prairie. Lincoln, Nebraska: Johnsen Publishing Co.

Dwight Platt

Module 34: Experimenting with color signals

Age level: Upper elementary and junior high

Subject: Biology **Theme:** Interdependence

Sequence: Post-field trip **Following:** Module 20

Objectives: To further investigate the functions of color signals; to design experiments to test hypotheses and to interpret the results of these experiments

Time required: Can be varied depending upon the number of experiments done

Materials required:

For section no. 2b:
- One or a few test birds in a cage (chickens, pigeons, or house sparrows). Keeping native species of birds in captivity is illegal.
- Grain (light-colored grain, such as rice or oats)
- Blue and orange food coloring
- Shallow pan
- A bitter or sour chemical (quinine hydrochloride, sucrose octaacetate, salicylaldehyde, p-benzoquinone, or acetic acid). SKEEC personnel may be able to help you obtain small quantities of one of these.

For section no. 2c:
- Test cage (open wooden box with glass plate to fit over top)
- Construction paper of two colors
- Live insects or spiders (bright-colored)

For section no. 3:
- Quick-drying blue enamel
- Quick-drying clear enamel
- Small brush

Investigation

1. Briefly review the study done in Module 20 and the hypotheses that were tested. Point out to the class that the observations made in Module 20 give a basis on which to decide which hypotheses should be further tested. Have the class choose a hypothesis that was supported by evidence and design an experiment to further test it. Help them to plan a design that will provide valid results. The following procedures suggest some possibilities but can be modified. The experiments will usually be done by the whole class.

2. Experiments to test hypotheses about the function of red, orange, or yellow coloration of insects.

   a. The first three hypotheses (see Module 20) are probably difficult to test with the resources you have available. However, do not rule them out if students devise some tests that will give relevant data.

b. The fourth and fifth hypotheses (Module 20) state that bright colors are signals that provide information of distasteful or dangerous qualities. Experiments can be designed to test whether a bird can associate a color signal with distasteful food items. Birds have color vision but a rather poor sense of taste. Birds that might be used as test animals are chickens, pigeons, or house sparrows.

(1) First an experiment should be designed to determine whether the test birds have an innate or already-learned aversion to orange food objects. Color some rice, oats, or other light-colored grain with orange food coloring, some with blue food coloring, and soak some in water without color. Count out 100 orange grains and 100 uncolored grains. Place these two piles of grain adjacent to one another in a shallow pan and offer them to a caged test bird in the morning before it is given other food. Place the pan so that the two piles are equally accessible to the bird. When approximately half of the grain has been eaten, collect the rest and determine how many grains of each color have been eaten. This test can be done with other individuals if more than one bird is available.

Make a similar test for blue grains and uncolored grains and for orange grains and blue grains. Which color of grain was eaten more readily each time? Even if the birds were not selecting for or against a particular color, would you expect the same number of grains to be eaten from each pile? Explain probability and chance events and determine if the difference between numbers of grains eaten in each two piles tested is significant (see Statement of Concepts).

Discuss the results with the class. Is there evidence that the test birds avoided colored grain? Does this avoidance apply to both orange and blue grain, or only one? If there is a specific avoidance for orange grain but not for blue, then the bird is responding to a specific color signal. If there is a specific avoidance for orange, do you think it is learned or is it innate or inborn? How could you test this hypothesis (answer to preceding question)?

(2) If there is no significant avoidance of orange grain over blue grain, design an experiment to determine if the bird can learn to avoid an orange food object. Color some grain with blue food coloring. Color some grain with orange food coloring to which has been added a bitter or sour chemical, such as quinine hydrochloride, sucrose octaacetate, salicylaldehyde, p-benzoquinone, or acetic acid. Count out 100 orange grains and 100 blue grains and put them in separate piles adjacent to each other on a shallow pan (the grain should be wet so that the taste is more readily detected). Offer them to a test bird as in experiment (1). Watch the bird's behavior to see if there is evidence that it detects a disagreeable taste on the orange grain. If it readily eats the orange grain, you will need to try another chemical or increase the concentration of the bitter or sour chemical used.

Offer the bitter or sour orange grain for three successive mornings. On the fourth morning, offer the bird 100 wet blue grains and 100 wet orange grains without the bitter or sour chemical. After the bird has eaten approximately half of the grain, remove the rest and determine how many grains of each color were eaten. Is there a significant difference between the number of orange grains and blue grains eaten? Did the bird select against the orange grains?

Test the bird again one week later. Does it select against the orange grain?

c. The sixth hypothesis (Module 20) states that bright coloration is a camouflage and that the animal spends much time on similar bright backgrounds. Design an experiment to test whether the animal selects a matching background. Collect some yellow, orange, or red insects or spiders that were observed on matching backgrounds on the field trip (Module 20). Construct a test cage, a wooden box with top open, with the floor covered with construction paper, one-half in a color matching the animal and one-half in a contrasting color. Illuminate it directly from above so that the light intensity on both halves is similar. Place one animal in the center of the test cage and cover the cage with a plate of glass. Let it explore the cage for 5 minutes. Now observe the animal every 3 minutes and record the color of the background on which it is standing. If it doesn't move much between observations, you may want to put it back in the center of the cage after each 10 observations. You can also test other individuals. After at least 50 observations, analyze the data to see whether the test animal spends more time on one color background than the other. Is the difference significant? Is there evidence that the animal selects a background of a matching color?

If there is no evidence that it selects a background of a matching color, could its bright color pattern still be a camouflage? How? Maybe it selects a certain flower on which to live and this flower provides a matching background. Can you design an experiment to test this? Maybe you can provide a test situation where it has a choice of two flowers.

3. Experiments to test whether insects respond to color signals in searching out flowers. This experiment will have to be done outdoors where there is a plant with many yellow or orange flowers. Observe the plant for a short time to see that there are insects visiting the flowers before choosing it for use in the experiment. With a quick-drying blue enamel, paint the outer two-thirds of each petal of at least 10 different flowers. Paint the outer two-thirds of each petal of at least 10 other flowers with a quick-drying clear enamel to serve as controls. Why should they be painted with clear enamel? Observe these flowers for a period of time to see if there is a difference in the insects that visit the blue-painted flowers as compared to the controls.

4. After doing the experiments designed by the class, discuss the results. Did the experiments provide evidence to support any of the hypotheses? Do you feel more certain about any of the hypotheses? State any conclusions you can make. Was the design of the experiment a good one? How could it be improved?

Statement of Concepts

See Statement of Concepts in Module 20.

Birds are important predators on insects. Most birds have color vision and can respond to color signals. Birds do not have a good sense of taste but there is evidence that taste can play a part in food selection. The chemicals listed in this module have been shown to be disagreeable in taste to some birds. However, taste has not been well-studied in birds and all of these chemicals may not be disagreeable to a particular species of bird used in an experiment.

Students should learn that a scientific hypothesis is a reasoned guess and may be based on a very limited amount of evidence. In a scientific study, hypothetical explanations are stated in order to plan observations that can provide evidence for or against them. An experiment is one of the most important methods that the scientist has of obtaining evidence so that he/she can decide which hypotheses to accept as explanations.

It is important that students learn the characteristics of a good experiment:

1. The results of the experiment should be predictably different if the hypothesis is correct or if it is incorrect.
2. There is a control and an experimental situation that differ only in the condition being tested. For instance, the bird can eat uncolored grain (control) or orange grain (experimental).
3. The experiment must involve a number of organisms or be repeated so that one can judge the reliability of the results. No conclusion could be made from an experiment in which a bird ate one uncolored grain rather than an orange grain.
4. The conclusions based on the results of the experiment can only be assumed to apply to the kind of organism tested and under the conditions of the experiment. Further experiments may show how widely applicable the conclusions are.

Each of the experiments in this module involve possible chance events. A chance event cannot be predicted specifically. Only its probability can be predicted. Tossing a coin is a chance event. You cannot predict any specific toss but you can predict that it has a 50% probability of being heads and a 50% probability of being tails. And if you toss it a number of times, you will expect approximately one-half heads and one-half tails, although usually not exactly one-half.

If a bird is not selecting grain of a particular color, then whether it picks a grain from one pile or the other is a chance event and one might expect half of the grain eaten to come from each pile if the piles are adjacent.

If an insect is not selecting a background of a particular color, then whether it stands on one background or the other at a specific time is a chance event; and if the two backgrounds are equal in size, half the time it should be on one background and half the time on the other. However, a series of chance events with two equally probable alternatives seldom end up with half one alternative and half the other. One alternative usually occurs a few more times than the other. If you toss a coin 100 times, you may get 53 heads and 47 tails. If you do it again, you may get 54 tails and 46 heads.

If the bird is really selecting a particular color of grain or the insect is selecting a particular background color (as stated in the hypotheses), then the event is not a chance event and one would expect the bird to eat more grain of the color selected or the insect to spend more time on the background selected. Interpretation of the experiments includes deciding whether the events are chance or not. As long as the difference between the numbers of the two alternative events is small, the events can still be happening by chance. If the difference becomes large enough that the probability of getting such a great difference in chance events is small, then the difference is said to be significant and the events are considered not to be chance events, but to be happening by choice or selection. Mathematicians have statistical tests for determining whether a difference is significant or not. In the experiments in this module, use the following table to determine whether a difference is significant or not.

If the total number of grains eaten or observations made is...	Then the difference between the two alternatives is significant only if the difference is equal to or larger than...
120	12
110	11
100	11
90	10
80	10
70	9
60	9
50	8

If the difference is too small to be significant, then you can assume that the events were happening by chance and there is no evidence of selection. If the difference is large enough to be significant, then you can assume that the events are not chance and there is evidence of selection.

References

See Module 20.

Paul G. Jantzen

Module 35: Illustrating roles in the food web and the importance of diversity (adapted from an experience with Dr. Wilson Clark, Eastern Montana College)

Age level: Elementary to high school

Subject: Biology **Theme:** Diversity and Interdependence

Sequence: Post-field trip **Following:** Modules 13, 15, 16, 21, 25 or 27

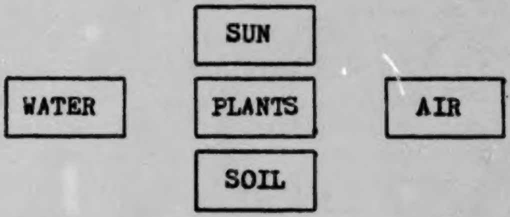
Objectives: To experience roles in a natural community; to experience the result of eliminating certain species from a natural community, and the importance of diversity

Materials required:

Individual cards with the words: PLANTS, SUN, WATER, SOIL, AIR
Stool, tripod, easel, or bulletin board on which to fasten the above cards in the front of the room
Cards and felt pen to make animal-name cards
Roll of heavy string
Scissors or knife for cutting string

Activity

Assemble a sturdy display in front of the students to illustrate that plants, the first link of any food chain, are dependent on soil, water, air, and the sun. The display should consist of an arrangement of cards fastened onto a stool, tripod, easel, or bulletin board with tacks or tape in an arrangement like this:



Near the PLANTS label, there should be a way to fasten many pieces of string such as a large screw hook, rung of a stool, or cross-piece of an easel.

Begin by asking which kinds of animals were seen on the field trip, or the kinds of animals the students have seen in a prairie community. As an animal's name is mentioned, it is written on both sides of a card and handed to a student who holds it up for all to see. The name may be very specific (white-footed mouse), or general (mouse). The more specific the name, the easier it is to find that animal's predators and food requirements in the literature, if no one remembers them from the field trip. The activity works best if there are enough students so that each one holds only a single card.

After a variety of animals have been named, a piece of string should join each pair of organisms that exhibit a predator-prey relationship. Herbivores should hold one end of a string, the other end of which is fastened near the PLANT label on the stool, easel, or bulletin board. One student, of course, may hold a number of strings running to foods and a number running to predators. If a predator's prey is not represented in the group, prepare a card for it and include it in the community. Additional prairie animals not seen on the field trip can be added, particularly if they would be useful in the following discussion.

All strings should be held taut. It is easy to see that this array of strings is more than a number of simple food chains. It is a food web of many crossing strands.

You can cite real or imaginary examples of drastic reductions of species population, some caused by man. For example, Nebraska farmers one year waged a war against the redwing because of its appetite for grain; (the following year, grain crops were ruined by locusts). In Georgia, hunters urged a bounty on marsh hawks thought to prey on quail; (actually the marsh hawk preyed on the cotton rat which is a glutton for quail eggs). In Pawnee County, Kansas, a community coyote hunt was organized to control that predator; (an increase in the jack rabbit population concerned wheat farmers at about that time). A several-year drought may reduce the frog population density.

As an example is cited, all strings leading to and from that animal species which has been eliminated or reduced are loosened and students are asked to predict specific effects on the community. If enough animal species are included in this simulation, competitors may "take over" for those species temporarily undergoing population reduction. For example, if the population density of bullsnakes is reduced, red-tailed hawks may find more mice available and more hawks will survive. The community equilibrium would be reestablished fairly easily. This shows how diversity helps to produce stability in an ecosystem.

The importance of diversity is seen when one considers the tenuousness of a simpler, less diverse food chain from the tundra (plant ⟶ lemmings ⟶ arctic fox or snowy owl). A radical change in one link guarantees drastic repercussions in the remainder of the chain. If grasshoppers in our area had only one predator, elimination of that predator would result in an uncontrolled grasshopper population increase until grasshoppers would severely damage the vegetation on which they feed. This would threaten all other herbivores and all organisms that depend on them.

If time allows, the leader might encourage students to point out additional, non-food interrelationships in this web. For example, bees aid in the cross-pollination of certain plants while gathering nectar and pollen. And several of the animals of the community may use plants for nesting and shelter as well as for food. Burrows dug by one animal may be used by other species.

If time is limited, or if students do not know the predator-prey relationships in the community, animal-name cards may be prepared ahead of time. And the names of predator and prey organisms can be written on the name cards to expedite the simulation.

NOTE: If a field trip is impossible, the film series, "Web of Life," might be shown. It consists of two films, "The Strand Grows" (18 minutes) and "A Strand Breaks" (18 minutes). These films are available for a $10 rental fee for each from:

Audio-Visual Center
University of Kansas
746 Massachusetts Street
Lawrence, Kansas 66044

Statement of Concepts

See Statement of Concepts in Modules 1, 5, and/or 6.

Food relationships in an ecosystem or community form food chains beginning with plants that capture sunlight energy and manufacture food. This food is passed along a food chain as one animal eats another. However, in a complex ecosystem, these food chains are interconnected to form food webs.

Additional diversity in an ecosystem due to additional species that have a specific niche (a specific set of interrelations; see Modules 5 or 6) in the ecosystem provides additional alternate relationships in the food web. This provides stability to the ecosystem. If a particular species is eliminated or reduced, its functions in the ecosystem can be "taken over" by other species with similar relationships.

References

For young students:

1. Billington, Elizabeth T. 1971. Understanding Ecology. New York: Frederick Warne and Co.
2. Gray, Robert. 1972. Links of life--food chains. Ranger Rick's Nature Magazine, vol. 6, no. 1, pp. 17-21 (January).
3. McCue, George. 1971. Ecology. New York: Benziger, Inc.
4. McCue, George. 1971. Ecology: The Grasslands and Man. New York: Benziger, Inc.

For the teacher or older students:

1. Allen, Durward L. 1967. The Life of Prairies and Plains. New York: McGraw-Hill, pp. 126-167.
2. Odum, Eugene P. 1971. Fundamentals of Ecology (3rd edition). Philadelphia: W. B. Saunders, pp. 148-154.
3. Smith, Robert Leo. 1974. Ecology and Field Biology (2nd edition). New York: Harper and Row, pp. 43-57.
4. Watt, Kenneth. 1972. Man's efficient rush toward deadly dullness. Natural History, vol. 81, no. 2, pp. 74-77, 80, 82.

Dwight Platt

Module 36: Some prairie animals that lost out

Age level: Elementary to high school

Subject: Biology **Theme:** Diversity

Sequence: Post-field trip **Following:** Modules 13, 17, 21, 25, 37, or 53

Objectives: To study the way in which man has affected some animals of the tallgrass prairie; to consider man's relation to the prairie and its wildlife

Time required: Minimum of 1 to 2 hours

Materials required:

One or more of the following films:

"Prairie Killers," National Educational Television (30 minutes)
"Buffalo, Majestic Symbol of the Plains," Walt Disney (12 minutes)
"North American Elk," Wild Life Films (10 minutes)
"Death of a Legend," National Film Board of Canada (50 minutes)

Activities

1. The tallgrass prairie has been more greatly modified by man than the other major prairie grasslands in North America. Show the class how large the original tallgrass prairie was (see Module 11, maps by Küchler, 1964, 1974; or map in Allen, 1967). The tallgrass prairie originally covered more than 400,000 square miles. The prairie soil proved to be some of the richest soil in the world. Most of this land has been plowed and cultivated. Even those parts of the tallgrass prairie that have not been plowed (the largest tracts are in the Flint Hills of Kansas) have been modified by their use as fenced pastures.

   Some animals have benefited from the changes man has made in the land. Trees have been planted on the prairies and some woodland animals have extended their ranges or become more numerous in the prairies. Ask the class if they can think of any examples. Some examples might be the Crow, Robin, Cardinal, and Fox Squirrel.

   Forests have been cleared in the East and have been replaced by cultivated lands or grasslands and some prairie animals have spread into or become more numerous in these areas. Some examples might be the Eastern Meadowlark, Lark Sparrow, and the Coyote.

2. But some prairie animals have declined in numbers because the changes have affected them adversely. Some of these were very important animals in the original tallgrass prairie so there is no area left today that is a replica of the original tallgrass prairie. Have the class make a study of the biology of some of these animals (see section no. 3) and the history of their interaction with man. This study can be done in one of the following ways:

a. For younger students, tell them the story of one of these animals. The Bison would probably be best since more information is available. The film, "The Buffalo, Majestic Symbol of the Plains," can also be used.

b. As a class, study one of these animals, assigning groups of students to get information on specific aspects of its biology and history.

c. As a class, determine what some of the factors were in the decline of these animals. Assign groups of students to get information on each of the species to be studied. Have each group report and then discuss the factors in the decline of the species studied.

d. Prepare cards for each of the animals detailing information about its biology--habitat, movements, food, enemies, etc. Divide the class into groups of 2 to 4 students. Give one card to each group. Ask the group to pretend that they are a pair or two pairs of the animal described on the card and they have recently arrived in this region. Have them consider how that animal might feel about living in the country around their community. This can best be done on a field trip to the country, although it could be done in the classroom. Have each group report to the class how they feel about this area and whether they intend to stay. This could be followed by a study of the history of each of these animals in the prairie area.

3. Some species to study are:

a. Bison Bison bison - once ranged over the entire tallgrass prairie. No wild or free-roaming Bison left in the area.

b. Wapiti Cervus canadensis - once ranged over all except the southern tallgrass prairie area. No wild or free-roaming Wapiti left in the area.

c. Gray Wolf Canis lupus - once ranged over the entire tallgrass prairie. The Plains subspecies became extinct in 1926. Other subspecies except those in Canada and Alaska are greatly reduced.

d. Eskimo Curlew Numenius borealis - Goss (1891) said, ". . . during the spring migration very abundant west of the Mississippi, where it assembles in large flocks upon the burnt ground and bare spots on the prairies, to probe for and feed upon the larvae and other forms of life . . ." Now on the federal list of endangered species and very near extinction.

e. Whooping Crane Grus americana - formerly was an uncommon but spectacular migrant through the prairies and also nested rarely around wooded marshes and lakes of the northern prairie. Now on the federal endangered species list; only about 50 wild birds survive.

f. Prairie Falcon Falco mexicanus - a bird of the open prairies, more common in the western prairies. Now reduced and listed as threatened in Kansas. A related species, the Peregrine Falcon, more common around ponds and lakes or streams is on the federal endangered species list.

g. Greater Prairie Chicken Tympanuchus cupido - formerly a common resident in the tallgrass prairies. Now extirpated in Iowa, Ohio, Kentucky, and Arkansas; greatly reduced in Illinois,-Missouri, Wisconsin, Minnesota, Michigan, and Indiana; still common in parts of Kansas, Oklahoma, Nebraska, and South Dakota.

Some other animals originally found in some part of the grassland area that could be studied are: Franklin's Ground Squirrel Spermophilus franklinii, Black-tailed Prairie Dog Cynomys ludovicianus, Pronghorn Antilocapra americana, Black-footed Ferret Mustela nigripes, Mountain Lion Felis concolor, Black Bear Ursus americanus, and Prairie Sharp-tailed Grouse Pedioecetes phasianellus.

4. Some questions that might be used to guide the study of older students are:

   a. Where was this animal originally found and how numerous was it?

   b. What was its general ecological niche in the prairie? How important was it to the prairie?

   c. Is it found in the tallgrass prairie area today? If so, where?

   d. What is the history of its relation to man? What are the principal factors that caused it to decline?

   e. How has the decline of this species probably affected the prairie community?

5. Discuss with the class the reasons for the decline of the species that have been studied. Point out that many of the practices that led to the decline of these animals were necessary in the development of agriculture. However, ask the class if the whole tallgrass prairie area should be used for agriculture and other purposes that satisfy the needs of man? Should some area be left for the prairie animals and plants? How would preserving a part of the tallgrass prairie ecosystem also be beneficial to man? What should man's relation be with the natural world around him? You can discuss some of the points made by Iltis (1972).

6. The following films can be used in the study of prairie animals or to stimulate discussion on man's relation to the prairie:

   a. "Prairie Killers" (on man's relation to the prairie)

   b. "Buffalo, Majestic Symbol of the Plains"

   c. "North American Elk"

   d. "Death of a Legend" (on wolves)

Statement of Concepts

The factors responsible for the decline of the 7 species listed probably include:

1. Loss of undisturbed prairie habitat by cultivation, grazing of domestic animals, and invasion of trees and shrubs.
2. Excessive shooting, particularly in the past, for the Bison, Eskimo Curlew, Wapiti, Whooping Crane, and Gray Wolf.
3. Poisoning and trapping, particularly for the Gray Wolf.
4. Fencing of the prairies, for the Bison and Wapiti.
5. Pesticide pollution may be a factor for the Prairie Falcon.
6. Taking of young birds for falconry may be a factor for the Prairie Falcon.
7. Inability to tolerate human disturbance may be a factor for the Whooping Crane.

References

1. Adrian, Mary. 1968. The American Prairie Chicken. New York: Hastings House. (Elementary)
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4. Bent, Arthur Cleveland. 1927. Life Histories of North American Marsh Birds. Smithsonian Institution U. S. National Museum Bulletin No. 135. (Dover reprint, 1963). (Whooping Crane)
5. Bent, Arthur Cleveland. 1929. Life Histories of North American Shore Birds (part two). Smithsonian Institution U. S. National Museum Bulletin No. 146. (Dover reprint, 1962). (Eskimo Curlew)
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Dwight Platt

Module 37: Management of grasslands--decreasers, increasers, invaders

Age level: High school

Subject: Biology

Themes: Diversity and Interdependence

Sequence: Post-field trip

Following: Modules 13, 18, 21, 22, 23, 26, or 36

Objectives: To explore the interdependence of the grassland plant community with the grazing animals that utilize it; to explore the effects on the grassland of different grazing management programs; to understand that grasslands under certain management programs are stable and sustain their productivity while other management programs cause deteriorating changes in potential productivity

Best season: Late summer or fall, but can be done at other seasons

Time required: At least 2 hours in the classroom and 1½ hours in the field, but more time will be needed if more than one grassland is studied

Materials required:

30-meter lengths of light rope - one length for each group of 3 or 4 students
Stakes - two for each group of 3 or 4 students
Sighting stick (a meter stick or similar straight stick 1 or 2 meters long, with each 25 centimeters marked) - one for each group of 3 or 4 students
Small metric rulers (if data is to be collected on utilization) - one for each group of 3 or 4 students
Film: "The Plow that Broke the Plains" (available on rent from SKEEC)

Activities

Part I. Preparation

1. Select one or more pastures for study in Part III (see Part III, section no. 1). If you plan to compare two or more pastures with different grazing programs, they should be near one another (preferably adjoining), on the same soil type, and with similar topography. (Soil types can be determined from the county soil survey; some soil surveys are available in the SKEEC library or they can be obtained from the county Soil Conservation Service office). The native prairie visited in the activities of a prior module can also be studied for comparison with the pasture(s), in which case the pasture(s) should be near and on the same soil type as the prairie.
2. Contact the owners or renters of the pasture(s) for permission to make the studies. Obtain information about the grazing history and stocking rates.
3. Obtain a list of decreasers, increasers, and invaders for the grasslands that you will be studying (see Statement of Concepts). Collect, identify, and press specimens of these plants as references for the class in their study (SKEEC personnel may be able to give assistance in identification).

Part II. Discussion of grasslands management

1. Grasslands may be managed for a number of different kinds of objectives. Ask the students to list types of management and their objectives. These could include:
    a. Management of cultivated grasslands for grain production (examples: wheat, milo, corn).
    b. Management of cultivated grasses for forage or hay production (examples: corn for silage, sudan grass).
    c. Management of cultivated grasslands, usually as monocultures, for aesthetic or cultural objectives (examples: lawns, parks).
    d. Management of native prairie grasslands for hay production.
    e. Management of native prairie grasslands as pastures for meat and/or milk production.
    f. Management of native prairie grasslands for wildlife and to maintain a natural prairie community.

    Some of these management programs involve much human effort, others very little. Some involve the removal of the native prairie community while others involve more or less modification of the prairie. But point out that each of the management programs will affect many members of the prairie community that are not directly managed. Man has managed prairie pastures by removing some of the original grazing animals and replacing them with other grazers. This affects some of the prairie plants and some other animals.

    Also point out that for each of these management programs there may be a number of strategies. Each strategy has its immediate returns. Some strategies may be sustainable, whereas others produce changes and the changed grassland may not give the same returns. A farmer may overgraze his pasture and receive higher returns for a few years because of the larger number of cattle he is able to produce. But this management strategy changes the pasture into one that can support fewer cattle.

2. Pastures are different than the original native prairie. Ask the students to suggest some differences that are the result of human management. Be sure the following are suggested in the discussion:
    a. Kinds of grazers--bison and elk replaced by cattle or sheep; also a number of kinds of large grazers replaced by usually only one kind of large grazer on a pasture.
    b. Number of grazers or intensity of grazing (proportion of the vegetation eaten by grazers).
    c. Duration of grazing--by fencing, grazers are kept on a restricted pasture day after day; in the original prairie, grazers wandered over large areas and grazing was periodic.

    What changes in the prairie plant community might be produced by these differences? Discuss with the class the differences in grazing selectivity by different grazers and the ways in which this might affect the prairie (see Statement of Concepts).

Part III. Study of pasture management

1. Introduce to the class some of the terminology and concepts of pasture or range management, including stocking rate, animal unit, carrying capacity, grazing capacity, utilization, decreasers, increasers, and invaders (see Statement of Concepts and Heady, 1975). Outline a study of one or more pastures to determine the effects of grazing management on the grasslands. One pasture can be studied to rate it as an excellent, good, fair, or poor pasture. Or the study can compare a number of grasslands with different grazing management programs (different grazing intensity or different grazing animals).

   Give the students information on the grassland(s) to be studied, including soil type, grazing history, and stocking rates. Give them the list of decreasers, increasers, and invaders for the grassland(s) to be studied. Show them the pressed specimens of these plants and point out characters by which to identify them (see Part I, section no. 3).

2. When you arrive at the first pasture, divide the class into groups of 3 or 4 students each. Give each group a 30-meter rope, two stakes, and a meter stick or a sighting stick with marks at 25-centimeter intervals. Each group will analyze the plants in the pasture, utilizing point transects. Exclude from the area to be sampled parts of the pasture that are abnormally disturbed, such as trampled areas along the fence or near water, salt, or supplemental food. The students may or may not use a random method for selecting the beginning point for and direction of each transect. Random methods must be used if statistical comparisons are to be made.

   Each group should stretch its rope and stake each end so that it is taut. Then members of the group should place the sighting stick along one end of the rope and record the plants lying directly underneath the mark at the end of each 25-centimeter interval on the stick. Plants that can be identified should be recorded by name, especially all those on the list of decreasers, increasers, and invaders. Plants that cannot be identified can be recorded as grass, forb, or shrub. When the plants under each point on the stick have been recorded, the stick should be moved to the next position along the line. This should be continued until all points at 25-centimeter intervals on the 30-meter rope line have been recorded. At least six transects should be done, but the data from all groups can be pooled to get a sufficiently large sample.

3 (optional). In addition to plant composition, utilization by grazers can also be studied. Ask each group to note for each plant recorded whether it is grazed or not and its height. Also each group should record other observations that relate to utilization, such as amount of litter, proportion of surface covered by plants, and evidence of wind or water erosion.

4. Repeat the process described in no. 2 (and no. 3) for any other grasslands that are to be studied.

5. Back in the classroom, summarize the data on the chalkboard. For each species of plant, an index of coverage or relative composition percentage can be calculated by counting the number of plants of the species recorded, dividing by the total number of plants of all kinds

recorded, and multiplying by 100. A relative composition percentage can also be calculated for all decreasers, for all increasers, and for all invaders. Each grassland should be characterized as excellent, good, fair, or poor as a pasture grassland (see Statement of Concepts for method). Comparisons can be made of decreasers, increasers, and invaders in grasslands under different grazing programs. Statistical comparisons can be made only if the sample transects were located randomly (see Statement of Concepts for a method of statistical comparison). If data have been collected on utilization, summarize these as a percentage of plants grazed, an average height of plants, and summary statement on other observations.

Discuss with the class the effects of different management programs on grasslands. Particularly consider changes in decreasers, increasers, and invaders. Also discuss differences in utilization if it has been studied. Point out that it would be important for the manager of a pasture not only to determine the present condition but also to determine changes or trends under the present management program.

Part IV. Historical study of grassland management

Show the film, "The Plow that Broke the Plains." Discuss the film:

a. Where did the events in the film take place? What kinds of grasslands were involved?

b. What were the important changes that occurred in the grasslands during the times depicted in this film?

c. What were some of the management practices that contributed to these changes?

d. Why were the practices adopted?

e. What management practices used today help prevent the problems shown in the film? What management practices used today might cause similar problems?

Statement of Concepts

A climax grassland is a relatively stable grassland community consisting of native plants and animals that can perpetuate itself indefinitely without human management. Disturbances change the climax, but the climax re-establishes itself in time when the disturbance ceases. Most human management practices are ecological disturbances to the climax. Many of these management practices make the community more productive for one or a few human purposes. However, some management practices change the community to lower its potential productivity for the management objectives. A pasture grassland may be rated from excellent to poor in terms of potential for producing harvestable grazing animals. Any management program that changes the grassland down the scale from excellent to poor is not sustainable and lowers the long term productivity even though it may produce high immediate short-term returns. Any grazing program that stabilizes the grassland on the upper end of this scale is sustainable over long periods.

The stocking rate of a pasture is "the number of animals in a pasture for a stated period of time." Stocking rates are generally expressed in animal units for a stated number of months or in animal unit months per year.

One animal unit is a mature cow with a calf (using 800 lbs. of forage per month) or their equivalent. A sheep is 0.2 animal units, while a horse or an adult bull is 1.25 animal units. The carrying capacity of a pasture is "the maximum number of individual animals that can survive the greatest period of stress each year on a given land area." The grazing capacity is "the number of animals that produces the greatest return without damage to the physical resources and in concert with other values received from the land." (Heady, 1975, pp. 114-117).

Grazing results in the clipping of leaves and stems of plants or defoliation and is usually measured as herbage utilization. Herbage utilization refers to the amount of plant material consumed by grazers, usually expressed as a percentage of the current herbage crop. A rule of thumb for good range management is that annual utilization should be approximately 50%, with 50% being left for litter and decomposition. Utilization includes the intensity of defoliation or the degree to which herbage is removed in one clipping; the frequency of defoliation or the number of defoliations and the interval of time between them; the season of defoliation, particularly with respect to the growth curve of the plant; and the selectivity of grazing or the grazing of some plants in preference to others.

In the original native prairie there were a number of different kinds of large grazers, each with a different selectivity in grazing. They usually wandered over a large area, so, although the intensity of defoliation was high when a large herd was present, the frequency of defoliation was low. On a pasture there is often only one kind of large grazer and both the intensity and frequency of defoliation are high.

Different kinds of grazing animals differ in their preferences for plants. However, utilization is always the result of both the preferences of the animals and the abundance of each kind of plant in the grassland. Therefore, the selective utilization pattern of a particular species in one grassland may be different than that of the same species in another grassland. The following table shows some gross differences in the utilization patterns of different grazing animals. However, since these studies were done by different methods in different grasslands, they are not strictly comparable. Browse are woody plants such as trees and shrubs. Forbs are non-grassy herbaceous plants.

Grazer	Percentage in Diet[1]				
	Browse	Forbs	Sedges, Grasses	Where Studied	Author
Bison	1%	2%	96%[2]	Wyoming	Meagher, 1973
Roosevelt Elk	21-34%	2-23%	56-76%	California	Harper, et al., 1967
White-tailed Deer	13%	69%	18%	Texas	Drawe and Box, 1968
Pronghorn Antelope	35%	51%	13%	Alberta	Mitchell and Smoliak, 197[illegible]
Cattle	6%	19%	75%	Texas	Drawe and Box, 1968

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[1] Animal grazing on plants may be different at different seasons. The percentages in the table are annual average percentages or the range of percentages at different seasons.

[2] The diet consisted of 61% sedges and 34% grasses.

Studies on the same grassland in Texas also show differences (McMahan, 1964):

Grazer	Range of Seasonal Percentages in Diet		
	Browse	Forbs	Grasses and Sedges
White-tailed Deer	48-100%	0-42%	0-11%
Cattle	0- 17%	1-11%	82-91%
Sheep	16- 31%	1-47%	37-82%

Selection is not limited to the broad categories used in the above tables but also can be seen in preferences for certain plant species. Tomanek, Martin and Albertson (1958) studied the preferences of cattle on a mixed grass range in western Kansas and concluded that Big and Little Bluestem were preferred; Side-oats Grama was eaten in proportion to its abundance; Western Wheatgrass was preferred in the lowlands but not on the breaks; and Buffalo Grass and Blue Grama were grazed without preference on the uplands but had negative preference ratings in the lowlands. Van Dyne and Heady (1965) studied preference ratings of sheep and cattle for plant species. The ratings are ratios of dietary composition to range composition with ratios larger than 1.0 indicating preference, and those below 1.0 indicating rejection. A few examples of preference ratings are:

	Sheep	Cattle
1. Canary Grass Phalaris tuberosa	9.9	2.7
2. Bermuda Grass Cynodon dactylon	8.5	0.9
3. Heron Bill Erodium botrys	1.2	1.8
4. Rushes Juncus sp.	4.8	0.9
5. Bromes Bromus sp.	0.9	1.0
6. Chickweed Cerastium sp.	9.9	3.2
7. Lupine Lupinus bicolor	0.5	1.6

Selectivity results in certain species of plants being utilized more intensively than others. When a pasture is heavily grazed, the abundance of various species of plant species will change. Some plants will decrease (decreasers) because they are utilized intensively and cannot compete with other plants that are utilized more lightly; other plants may increase in abundance (increasers); and other plants not normally present in the climax grassland will invade the grassland (invaders) because the climax species have been weakened by grazing. Many invaders are annual plants and replace perennial plants of the climax grassland. These changes, if extensive, lower the productivity of the grassland for the grazers.

The following plants are decreasers found in sand prairies (like Sand Prairie Natural History Reservation) in western Harvey County, Kansas. Those marked with A are always present; those marked with NA are not always present. The percentages are the usual percentages of yield in the climax grassland.

1.	Sand Bluestem	A 25-49%	6.	Sand Lovegrass	NA 10-24%
2.	Big Bluestem		7.	Big Sandreed	NA $< 10\%$
3.	Little Bluestem	A 25-49%	8.	Silky Prairie Clover	NA $< 10\%$
4.	Switchgrass	NA 10-24%	9.	Virginia Tephrosia	
5.	Indiangrass	NA 10-24%	10.	Leadplant	NA trace

Increasers in the sand prairies and their maximum percentages in the climax grassland are:

1.	Blue Grama	5%	6.	Purple Lovegrass	trace
2.	Hairy Grama		7.	Rosette Panicums	5%
3.	Sand Dropseed	5%	8.	Western Ragweed	10%
4.	Sand Paspalum	5%	9.	Missouri Goldenrod	
5.	Fall Witchgrass	5%	10.	Chickasaw Plum	5%

Invaders in the sand prairies are:

1. Rosering Gaillardia
2. Sixweeks Threeawn
3. Prairie Threeawn
4. False Buffalograss
5. Annual Eriogonum
6. Texas Croton
7. Sixweeks Fescue
8. Bristlegrass
9. Sandbur
10. Other annuals

Lists for other grassland types can be found in "Range Condition Guides and Technical Range Site Descriptions for Kansas" (available in the SKEEC Library or from USDA Soil Conservation Service).

Pastures can be rated by range condition percentages. Range condition percentages are calculated by adding the relative composition percentages for all decreasers and adding the relative composition percentages for each increaser only up to the maximum percentage listed above. Native grassland pastures can then be rated as excellent if range condition percentages are 76 to 100%, good if 51 to 75%, fair if 26 to 50%, and poor if 0 to 25%. Suggested stocking rates on excellent sand prairies are 1.4 animal unit months/acre, on good sand prairies 1.0 animal unit months/acre, on fair sand prairies 0.7 animal unit months/acre, and on poor sand prairies 0.45 animal unit months/acre.

Statistical comparisons to determine if the differences between the numbers of decreasers (or increasers or invaders) on two pastures are significant can be made by the chi-square method:

$$\chi^2 - \Sigma \frac{(X_A - X_B)^2}{X_B}$$

where:

χ^2 = the chi-square value

Σ = summation of the ratios for presence and for absence of decreasers

X_A = number of points at which a decreaser was present (or absent) in pasture A

X_B = number of points at which a decreaser was present (or absent) in pasture B

If the number of points recorded in one pasture are greater than in the other, the data for the pasture with the greater number of points must be adjusted in proportion to the number of points in the other for making the chi-square test.

The chi-square value obtained is compared to the values in a chi-square table for one degree of freedom to determine the significance of the differences. For example:

	X_A	X_B	$X_A - X_B$	$(X_A - X_B)^2$	$\frac{(X_A - X_B)^2}{X_B}$
Number of points with a decreaser	510	620	-110	12100	19.5
Number of points with no decreaser	290	180	110	12100	67.2
Total	800	800			$\chi^2 = 86.7$

From a chi-square table, probability = $< 0.5\%$. So the difference is significant at a 1% level of significance.

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Dwight Platt

Module 38: Habitats for wildlife

Age level: Junior high and high school

Subject: Biology **Themes:** Diversity and Interdependence

Sequence: Post-field trip **Following:** Modules 13, 16, 17, 19, 20, 21, 25, 36, 37, 39, or 53

Objectives: To learn about the characteristics of good wildlife habitat; to understand the importance of diversity in wildlife habitat; to learn how to, and to develop a concern to, improve wildlife habitat

Time required: A minimum of 3 hours, although more time will be involved if Part III is done

Materials required:

Poster paper
Rulers and/or measuring tapes as needed
Other materials will be needed to implement the habitat improvement plans

Activities

Part I. Discussion of wildlife habitat

1. Discuss with the class the nature of good wildlife habitat (see Statement of Concepts). Point out:
   a. That it must satisfy needs for food, cover, and water.
   b. The importance of diversity to wildlife habitat.
   c. The nature of carrying capacity and limiting factors.
   d. The importance of interspersion and edge effect.

2. Point out that different wildlife species are on a continuum:

   wilderness species ⟶ species living in close association with man

   To provide habitat for wilderness species requires action by government or larger segments of society. However, one individual may be able to improve habitat for species on the right end of the continuum.

Part II. Planning for habitat improvement

1. Write "Food," "Cover," and "Water" at the top of different sections of the chalkboard. Then ask the class to suggest ways in which an area of land, such as a yard or farm, might be improved to better satisfy these needs of wildlife. List improvement practices under the proper heading as they are suggested by students. Some improvement practices that should be included in the discussion are:

Food

a. Plant different kinds of perennial plants that will supply fruit, seeds, nuts, browse, grass forage, and forbs at different seasons of the year.

b. Plant or maintain some annual food patches--grains, weeds, etc.

c. Maintain some weedy or shrubby patches where there will be insects or other small animals as food for insectivorous and carnivorous species.

d. Keep some litter of leaves and dead plants on the ground in which small animals will live that provide food for animals that feed on the ground.

Cover

a. Plant or maintain small shrubby and tree areas that can provide escape and/or nesting cover for different species.

b. Construct brush piles of dead limbs or cuttings 3 to 4 feet high that are loose enough close to the ground that animals can escape into them.

c. Allow some dead trees or limbs to stand to provide nesting sites for some species.

d. Keep some tall trees or other structures that can serve as perches.

e. Plant or maintain hedges, windbreaks, or native cover in fencerows.

f. Openings or lanes in woods or shrub thickets make them more useful to many wildlife species.

g. Include both evergreens and hardwoods.

h. Maintain ground litter as shelter for some species.

i. Construct nesting boxes or structures.

Water

If sufficient natural water is not present:

a. Establish water holes at springs or in seepage areas.

b. Construct small pools or ponds.

c. Provide supplementary water in bird baths or other watering devices when natural water is not available.

Emphasize the importance of interspersion and the provision of edge. Also emphasize that practices dangerous to wildlife, such as the use of pesticides, should be minimized in any wildlife area.

2. Make an assignment that involves planning for improvement of an area for wildlife. This could be done in one of the following ways:

a. Have the class select some areas, such as a portion of the school grounds, a park, a streamside, a wildlife refuge, etc. Assign a group of students to make a habitat improvement plan for each area. Give each group two large sheets of poster paper and some measuring instruments. The group should first make a map of the area as it is now, showing the plant communities and the important kinds of plants that are there. They should then make another map of the area showing improvements that might be made for wildlife.

b. Ask each student to pick an area, such as his/her yard or an area on his/her family's farm or a friend's farm and make plans for it as in a above.

c. Ask each student or group of students to design an idealized wildlife area. This should be done only if it is not feasible to relate the plans to actual sites as in a or b above.

Make available to the students some of the references listed at the end of this module or other references to use as resources in their planning. Helpful information can also be obtained from the Kansas Forestry, Fish and Game Commission and the U.S. Soil Conservation Service.

3. After the plans have been completed, you may want to have a class discussion of the plans and their feasibility, especially if the class has chosen the areas and the plans have been developed in groups. If the assignment has been done as an individual task, you may want to discuss his/her plan with each student.

Part III. Implementation of a habitat improvement plan

If at all possible, some aspects of one or more of these habitat improvement plans should be implemented. This can be a class project. Even if many aspects of the plan are not feasible to implement, it is usually possible to find some aspect that can be done. If the plans have been done individually for the student's own yard, help them to see some aspects of the plan that they might implement with the cooperation of their parents. Some students may want to enter their yard in the National Wildlife Federation's Backyard Wildlife Program (see Bourne, 1974, pp. 184-185).

Statement of Concepts

Habitat must be able to satisfy an animal's needs for food, cover, and water. Different animals have different food requirements, so there must be a diversity of plants in the habitat to support a diversity of wildlife. There must be some plants to supply fruits, seeds, nuts, foliage, bark, and roots. Some animals must find other animals for food. Plants vary from season to season in their nutritional properties. Food must be available in the habitat to supply the needs of an animal throughout the year or at least during the seasons when the animal is present and active (for an animal that migrates or hibernates). Also, during the reproductive season there must be sufficient food for raising the young.

Cover may serve a number of functions. It may serve to modify the physical conditions of the environment, such as temperature or humidity extremes, or to provide shelter from wind or storms. Escape cover may hide the animal from its predators. Cover for reproduction may be necessary to support or shelter a nest. Open areas may be important for some species. Cover may be provided by certain types of growing plants, such as shrubs or dense grass, or it may be provided by dead plant litter, such as the dense litter in which prairie voles make their runways.

Drinking water must also be available for most animals within range of their normal movements. Many birds can fly long distances to water from habitat which supplies their other needs. However, small mammals or lizards must find water nearby. Dew is often an important source of water for animals during the summer.

The carrying capacity of a habitat for a particular wildlife species is the maximum number that can be supported without harming the habitat. The carrying capacity is usually determined by that resource that is available in minimal amounts. Other resources may not be completely utilized. The resources or factors that are determining the limits of the carrying capacity are the limiting factors. If suitable nesting sites are in short supply, the numbers of a particular bird may be limited even though there is excess food available. To most effectively improve a habitat, the limiting factors must be improved.

Since many animals need more than one kind of habitat, the interspersion of habitats with much edge between them is important. For instance, a bird may need shrubbery for nesting but open areas of grass for feeding. The edge between two habitats, such as the edge of a woods or a shrub thicket, is usually richest in a diversity of wildlife. Many small shrub thickets interspersed in a grassland can support more wildlife than can a large shrub thicket because there is more edge. This is known as the "edge effect."

Some species of wildlife are wilderness species. Species such as Whooping Cranes, Ivory-billed Woodpeckers, or Gray Wolves need undisturbed wilderness to prosper and have difficulty living in association with man. Preservation of large wilderness areas is important to these species. Some species are only found in close association with man and are adapted to the habitats produced by complete human management. House Sparrows or House Mice are examples of such species. Other species are found on a continuum between these two extremes. A person can do much to improve the area where he lives as habitat for some of the species, such as squirrels, cottontails, pheasant, bobwhite, many songbirds, and other animals, that can live in association with man and limited amounts of human disturbance.

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Dwight Platt

Module 39: What good is it?

Age level: Can be adapted for elementary through high school

Subject: Biology **Theme:** Interdependence

Sequence: Post-field trip **Following:** Modules 13, 15, 16, 17, 19, 20, 21, 25, 35, 36, or 38

Objectives: To develop a close relationship with and appreciation for a prairie animal; to understand that each animal fills an interdependent niche within the prairie community; to recognize that each animal has a value because of the role it plays in the prairie community

Time required: Short periods of time for discussion and time for research over a period of about 2 weeks

Materials required:
Cage with a prairie animal (may be available on loan from SKEEC)

Activities

Keep a small prairie animal in a cage in the classroom. A snake, a lizard, a turtle, or a small mammal is suitable. It may be trapped in the field or SKEEC personnel may have a prairie animal in captivity that you can borrow for a few weeks. When the animal is first brought to the class, assign an exercise that will permit students to express how they feel about the animal. They may write a short essay, a poem, or draw a picture.

Students should take turns according to a schedule in caring for the animal. Do not set up a mandatory schedule as some students may be afraid of the animal. However, give all students a chance to volunteer for the schedule.

Ask the students to do some research to find out what the animal eats. Discuss the food of this animal with the class and decide what would be best to feed it while it is in captivity.

After the animal has been in the classroom for about week, ask the students: What good is it? What harm is it? Discuss these questions. The students will probably suggest ways in which this kind of animal is beneficial or harmful to man's interest. Encourage this and make a list on the chalkboard of those points suggested by the students.

During the next week, the class should do more research on the ecology of the animal. You can assign some readings and/or you can read some articles about the animal to the class. Ask the students to bring to class any information they can find about this animal.

At the end of this week, ask the class again: What good is it? This time guide the discussion to consider the place of this animal within a prairie community. Ask the class to list all the relationships that it has with other prairie animals or plants. You can extend this to secondary effects. For instance, a garter snake is fed by a frog which, in turn, has fed on beetles. Point out that this animal has "tasks" to perform in the prairie community--that it fills a necessary niche. Therefore, it has a value to the prairie community (see Statement of Concepts in Module 5 for an interpretation of the value of these relationships). Few species are indispensable to a community, but each has a contribution to make. For it is in the interactions between the many members of a prairie community that the stability of the community lies.

Be sure that the students are regular in feeding the animal and giving it water. Make sure that they keep the cage clean. Emphasize that animals live better in the wild and, if they are kept in captivity for a short time, they must be well cared for. Return the animal to SKEEC or to the field before the care of it becomes a drudgery. Make a point of returning the animal back to the wild.

Statement of Concepts

See Statement of Concepts in Modules 5 and 6.

References

SKEEC personnel can help you find references on the animal you are keeping in captivity.

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Dwight Platt

Module 40: Seasonal rhythms and seeds

Age level: High school

Subject: Biology   **Theme:** Rhythms

Sequence: Post-field trip   **Following:** Module 28 (or in conjunction with it)

Objectives: To study the dormancy and germination of seeds by experimentation; to become aware of adaptations in seed germination that time the growth of plants to favorable times in the seasonal rhythm in a prairie

Time required: Minimum of 3 hours spread over about two months

Materials required:

Seeds of prairie plants (collected in field)
Vials or other containers
Refrigerator in which to place vials of seeds for cold stratification
Plastic sandwich boxes for testing germination - one for each group of seeds
Blotters or paper toweling

Activities

1. Ask the class how many have grown a garden. How many have grown a fall garden? Do most garden seeds germinate in either spring or fall whenever they are planted? Assign written or oral reports on seed germination. Have the students find out:

   a. What occurs in a seed when it germinates.

   b. What conditions are necessary for seed germination.

   Discuss the reports. Be sure the following are understood:

   a. The seed contains a small embryonic plant that stopped growing upon maturation and dehydration of the seed.

   b. Before germination the seed must imbibe or absorb water and become hydrated.

   c. Germination involves the activation of embryonic growth areas.

   d. Favorable moisture, temperature, and atmospheric composition are necessary for germination.

2. Discuss the germination of seeds in a prairie. If Module 18 has been completed, discuss what was discovered about the activity of plants at different seasons. Prairie seeds are "planted" as soon as they are shed from the parent plant and get in the soil, but they usually germinate and grow at a later season. Many prairie plants produce seeds in spring or summer, but the seeds do not germinate until the next year even though conditions appear to be favorable for germination in fall.

Discuss the nature of seed dormancy (see Statement of Concepts). Emphasize that:

a. Dormancy may be of different kinds and depend upon different mechanisms.

b. Dormancy may restrict seed germination to the best time in the seasonal cycle.

c. Dormancy may also serve other adaptive purposes (see Statement of Concepts).

Discuss after-ripening and the mechanisms for breaking seed dormancy. List those that can be used experimentally and those that probably operate in a natural prairie ecosystem (see Statement of Concepts). Point out that exposure of imbibed seeds to cold temperatures is important in breaking seed dormancy for many plants of temperate zones. It will often increase the percentage of seeds germinating even if some germinate without cold treatment. Suggest that the class experiment with cold stratification of some seeds of prairie plants.

3. You will need seeds of some prairie plants which will need to have been collected in the field at the proper season. Consult Rock (1972) for information on seeds that will respond to cold stratification. SKEEC personnel can help you select and find seed. If the seeds are in dehiscent or fleshy fruits, remove them from the fruits as the fruit will sometimes inhibit germination.

A single experiment can be planned and done by the whole class or experiments can be done by small groups of students. Design an experiment to test the effects of cold stratification. An experimental group (seeds subjected to six weeks of cold stratification) and a control group (seeds that are not cold stratified) should be included. At least 50 seeds will be needed for each group. (Larger samples should be used if enough seeds are available). You can add other experimental groups to test the effects of different periods of cold stratification or of different treatments, such as cold treatment while dry or treatment with fluctuating temperatures rather than continuous cold.

To stratify seeds, place larger seeds in moist sand in vials or other containers. Small seeds, which would be difficult to separate from the sand, can be packed in wet toweling. Place the containers of seeds in a refrigerator where the temperature will be between 1°C (34°F) and 10°C (50°F). (See Klein and Klein, 1968, pp. 57-58, or Rock, 1972, for more information).

Test the germination of each group of seeds at the same time and under the same conditions. Spread out the 50 seeds on a wet blotter or a number of pieces of wet paper toweling in the bottom of a plastic sandwich box. Place another moist blotter or piece of toweling over the seeds and put the lid on the box. Keep the boxes at room temperature and check to see that they remain moist. Terminate the experiment when most of the seeds that will germinate initially have done so. This may require from 5 to 20 days depending upon the type of seed. Now count the number of seeds that germinated (root tip has broken through seed coat) and the number that did not germinate in each group. Did cold stratification affect the germination of these seeds? The results can be tested statistically by the chi-square method to see if the differences are significant (see Statement of Concepts). The vigor and rate of growth can also be compared by measuring the average length of the root in each group of seedlings.

Discuss the way in which a requirement for cold temperature might time the germination of seeds to the seasonal rhythms in the prairie. Do some prairie seeds germinate in the fall? What kinds of plants are these and what adaptations do they have? What would happen if seeds of other kinds of prairie plants germinated in the fall? (See Statement of Concepts).

4. Further experiments with other methods of breaking seed dormancy can be done. Klein and Klein (1968) give some ideas.

Statement of Concepts

In order to germinate, seeds must first absorb water and become hydrated, a process known as imbibition. The imbibed seed will then germinate if the embryonic root tip and shoot tip are activated to resume growth. Germination can occur only if moisture is sufficient, temperatures are within a favorable range, oxygen is sufficient, the seed can imbibe water, and the embryo is in a physiological state in which it can resume growth.

Some seeds will germinate almost immediately after being shed by the parent plant if conditions are favorable. A few kinds of seeds will die very soon if conditions are not favorable for germination. However, most seeds will remain viable and capable of germination for many years (maximum more than 200 years). However, they may not germinate whenever conditions become apparently favorable. Seeds that do not germinate when placed under favorable conditions and yet are alive and viable are said to be dormant. Seeds that do not germinate when shed from the parent plant, but do after a period of time, are said to need after-ripening.

All of the seeds produced at one time may not have the same period of dormancy. There are two seeds in the bur of a cocklebur and one usually germinates a year later than the other.

Dormancy may be relative, in which case the dormant seeds may germinate, but only within a very narrow range of favorable temperatures (often very high or very low) or under certain light conditions. Breaking such relative dormancy is a process of widening the temperature range or eliminating the light requirement for germination.

Some seeds that have been after-ripened or are capable of germination may enter a secondary dormancy if exposed to certain conditions that do not permit germination, such as drying, too high or too low temperatures, etc.

The mechanisms of dormancy are not all known. Some mechanisms that have been demonstrated are:

a. A seed coat impermeable to water, oxygen, and/or carbon dioxide.

b. A hard seed coat that mechanically constrains the embryo.

c. Morphological or physiological changes in the embryo are necessary before growth can occur--may involve activation of an enzyme system, production of a hormone, change in composition of storage compounds, etc. Some dormant seeds can be made to germinate by extreme measures like removing cotyledons, but growth will be stunted and abnormal until the seedlings are given a treatment that normally breaks dormancy.

d. Inhibitory chemicals may be present in the seed or in the fruit coat that prevents germination.

Many dormant seeds will germinate after a period of after-ripening in dry storage that may vary from a few days to seven years. However, there are also specific treatments that will break dormancy in many seeds:

	Used Experimentally	May Operate Naturally
a.	Processes that weaken seed coat and make it more permeable: physical scratching or breaking (scarification), shaking to knock out wax plugs, freezing, very high temperature, or chemical treatments, especially with wax solvents.	Processes that weaken seed coats: physical scarification, digestive action in animal intestine, decomposition, or freezing.
b.	Increasing oxygen tension.	- - -
c.	Cold stratification (treatment of imbibed seeds with cold temperature).	Period of cold temperature while seed is in moist soil.
d.	Exposure of imbibed seeds to daylight (or red light) for short or long periods. (Light inhibits germination in some seeds).	Germination occurs only on or near soil surface where light reaches seed.
e.	Treatment with various chemical germination stimulators.	Certain naturally occurring hormones, such as gibberellic acid, stimulate germination in some seeds.

Some seeds require two cold treatments. After the first treatment, the root will grow under favorable conditions but the epicotyl or shoot remains dormant. Only after root growth, a second cold treatment will break the epicotyl dormancy. (For more complete discussions of seed dormancy, see Crocker, 1948; Mayer and Polzakoff-Mayber, 1963; and Vegis, 1963).

Seed dormancy may have a number of adaptive functions. It may keep seeds from germinating when they are so deeply buried that the shoot could not reach the surface. It keeps a reserve of seed from each season's crop in the soil for many years. This gives security against a seed crop failure or a disturbance that might kill the living plants of that species in a field (Example: weeds that keep sprouting in a field after a number of years of clean cultivation or herbicide spraying). But one of the most important functions is to time germination to the most favorable season in the annual seasonal rhythm. The treatments necessary to break dormancy are environmental signals that normally allow germination to occur in the season that is most favorable for the growth of the plant. In temperate climates, seeds of winter annuals or biennials may be adapted to germinate in late summer or fall and grow to a stage that can survive the winter. However, if seeds of other prairie plants were not dormant and instead germinated in the fall, the seedlings would be killed by the sub-freezing temperatures of winter.

The difference between the germination of seeds in the experimental and control group can be tested by the chi-square method:

$$\chi^2 = \sum \frac{(X_E - X_C)^2}{X_C}$$

where:

χ^2 = the chi-square value

$\sum$ = summation of the ratios for seeds that germinated and for those that did not

X_E = number of seeds that germinated (or did not germinate) in the experimental group

X_C = number of seeds that germinated (or did not germinate) in the control group

The total number of seeds in both groups must be the same or must be adjusted in proportion for making the chi-square test. The chi-square value obtained is compared to the values in a chi-square table for one degree of freedom to determine the significance of the difference.

Example:

	X_E	X_C	$X_E - X_C$	$(X_E - X_C)^2$	$\frac{(X_E - X_C)^2}{X_C}$
Germinated	35	18	17	289	16.06
Not germinated	15	32	-17	289	9.03
Total	50	50			$\chi^2 = 25.09$

From a chi-square table, probability = $< .05\%$. So the difference is significant at a 1% level of significance.

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Dwight Platt

Module 41: Growing prairie plants

Age level: Junior high and high school

Subject: Biology **Theme:** Diversity

Sequence: Post-field trip **Following:** Modules 18, 22, 23, 24, 26, 28, 33, 37, 40, or 43

Objectives: To learn about the growth and reproduction of prairie plants; to become more familiar with and develop an appreciation for a few prairie plants; to learn to appreciate the usefulness and beauty of native prairie plants in landscaping and small prairie gardens

Time required: At the discretion of the teacher

Materials required:

Seeds or other propagules of prairie plants (SKEEC personnel can help you obtain and identify them)

Containers in which to grow plants

Activities

1. Discuss with the class ways in which prairie plants can be used in cultivation:

   a. In landscaping and small gardens (Anonymous, 1971; Hutchinson, 1973; Sill, 1973).

   b. As roadside cover for beauty and for wildlife (Ode, 1972; Landers, 1972; Landers, *et al.*, 1970).

   c. In erosion control and as forage for pasture or hay.

   What advantages do prairie plants have for these uses in Kansas? Point out that they take less care and are more drought resistant than most non-native plants.

2. Growing prairie plants is one way to gain a greater appreciation for the prairie. As a follow-up to studies in a prairie, you can initiate a class project or individual student projects in growing some prairie plants. Many prairie grasses and forbs can be grown from seeds or by transplanting and you can start them by growing them in your classroom. You may have some plants that were collected on a field trip or seedlings from experiments with seed germination that can be kept in the classroom. Or you can take a field trip to collect some seeds or find a few plants to transplant. SKEEC personnel can help you decide what to grow and where seeds or plants might be found.

   Many seeds of prairie plants require treatments before they will germinate (see Module 40). Most of the prairie grasses can be easily grown from seed, including Big and Little Bluestem, Indian Grass, Switchgrass, Western Wheatgrass, and Side-oats Grama. Some forbs that grow easily from seed are Prairie Coneflower, Compassplant, Blackeyed Susan, goldenrods, sunflowers, some asters, some milkweeds, anemones, and evening primroses. Most of the grasses can be transplanted from the field readily. Forbs that transplant readily include wild onions, anemones, asters, Purple Coneflower, perennial sunflowers, some blazing stars, some evening primroses, prairie clovers, Compassplant, Blue-eyed Grass, goldenrods, spiderworts, verbenas, and violets. However, only take a few plants for transplanting from large colonies in the field or where development will soon destroy their habitat anyway. Do not destroy wild stands of prairie plants in getting plants for your classroom. Although you will have to experiment with many plants to find the best propagation techniques, helpful information about the growing of prairie grasses and forbs can be found in Rock (1972). Other references with useful information are Taylor and Hamblin (1963) and Zimmerman (1972).

3. In growing prairie plants, students can learn much about the propagation of plants. They may need to make cuttings of roots or stems. They may need to stratify or scarify seeds to make them grow. They can see how slowly the shoot grows and how rapidly the roots grow in prairie plant seedlings. The project will be more meaningful if the plants grown in the classroom can be used to start a small prairie garden or landscaping project on the school grounds, in a park, or elsewhere. If started in peat pots, they can be transplanted very easily (Vocelka, 1970). The plants can then be studied for many years by a number of classes. Some plants will bloom the first year while others must be a number of years old before they will bloom. Some prairie plants will live to be 20 or 30 years old.

4. When growing prairie plants, the students will be interested in learning more about them. There are some studies of specific kinds of prairie plants and their ecology, like the study by Menhusen (1973) about blazing stars. Information about prairie plants, their ecology and uses can be found in Stevens (1961), Weaver (1954), and Anonymous (1963). Stories or essays, like the essay, "Prairie Birthday," about the Compassplant in Leopold (1949), will add to an appreciation for the plants. Some of the information about the height of the plant and season of bloom in these books and in Rock (1972) will be helpful in planning a prairie garden. As the students learn more about prairie plants, encourage them to be concerned for the preservation of prairie plants along roadsides and in other small wild places. Help them distinguish between native prairie plant cover and the introduced species, like Smooth Bromegrass, or the weedy species favored by present roadside management programs.

References

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Dwight Platt

Module 42: A study of garbage

Age level: Elementary and junior high school

Subject: Biology **Theme:** Rhythms

Sequence: Post-field trip **Following:** Module 27

Objectives: To learn more about decomposition; to contrast cyclic and linear flow of matter; to study the decomposability of components of trash and garbage; to develop concern for encouraging cyclic flow methods such as composting, reuse, and recycling

Time required: Minimum of 2½ hours spread over 4 to 6 weeks

Materials required:

Plastic sandwich box for decomposer garden
Low-power microscope or high-power hand lens
Small plastic cartons or milk cartons (four for each item to be tested)
Items from garbage or trash

Activities

1. Review what the students have learned in Module 27. What happens to worn out structures and waste material in the prairie? It is decomposed and the nutrients recycled. Start a decomposer garden to watch some of these recyclers in action. Take a plastic sandwich box and sprinkle a little soil in it. Take a few pieces of undecayed waste food (orange peel, bread, potato, etc.) and put them on top of the sprinkling of soil. Moisten the soil and pieces of food and put the lid on the sandwich box. Keep the box at room temperature and examine it every day. Study the growth of molds and the changes that occur in the food pieces. Look at the fungi with a low-power microscope or high-power hand lens to see the mycelia of the molds and the development of spores (see Statement of Concepts). Talk to the class about the smaller decomposers, yeasts, bacteria, and protozoa, that are more difficult to see but do much of the decomposition.

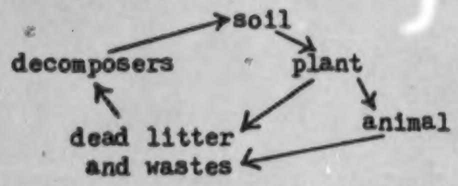
2. What happens to waste--trash and garbage--in your community? You may want to take the class to visit the sewage plant and/or the sanitary landfill and have the manager(s) explain how the wastes are handled. Alternatively, you can ask someone from the city government to talk about the work of the Department of Sanitation.

   Back in the classroom, ask the class what happens to the raw materials or nutrients in the waste from your community. Point out that in the sanitary landfill, they are locked up underground and from the sewage plant they go down the stream and into the ocean. Diagram some pathways on the chalkboard as follows:

mine → factory → consumer → sanitary landfill
(resource) (dump)

soil → food → sewage plant → stream → ocean
(resource) (dump)

Contrast these with the cycle of nutrients in the soil of the prairie:



Point out that the linear flow in the first two diagrams results in changes that can lead to problems. What changes occur in the resource and in the dump? The resource may become depleted and the dump may get too full. The rhythmic or cyclical pattern results in a sustainable system with a minimum of change.

If your students are older, read Lopez (1973) and then present some of his ideas on linear and cyclical thinking to them.

3. Ask the students if any of the wastes from your community can be decomposed and recycled by the soil community as in the prairie. Set up experimental soil communities to find out. You should test items such as pieces of plastic, pieces of paper, eggshell, orange peel, lettuce, aluminum foil, etc. For each item to be tested, get four small plastic cartons or small milk cartons. Fill each carton halfway with rich moist soil. Place a small piece of the item in each of the four cartons, cover them with more soil, and label each carton. Do the same for each of the other items to be tested. The cartons should be kept at room temperature. Keep the soil moist but not overly wet. At the end of one week, empty one carton of the four for each of the items and examine the item to note its condition and to see if any decomposition has occurred. Do the same at the end of each of the next three weeks. Which items decomposed most rapidly? Which did not decompose at all?

   Discuss the process of decomposition of waste with the class. Which items in garbage and trash can be decomposed by soil organisms? This is composting. What can compost be used for? Does composting result in a cyclical flow of matter?

   (optional). You can have the class experiment by building a small compost pile. Observations can be made on the process, including the heat that is released by microbial decay. This heat can also be observed by making a tightly packed moist pile of grass clippings or leaves and then recording its temperature. For information on composting, consult Schatz and Schatz (1971, pp. 22-23) and Rodale (1967). Are there ways in which the class can encourage more composting in your community?

4. Ask the class what can be done with wastes that cannot be decomposed by soil organisms. Make a list of suggestions on the chalkboard. Be sure they include:

   a. Reuse. Some plastic and glass bottles can be used again. Should more beverages be sold in this type of container?

b. Recycling. Many materials can be recycled to make new objects. Metals can be recycled. Paper is often better recycled than composted. Glass can be recycled to make more glass, or crushed glass can be used instead of rock or gravel in construction materials.

Point out that reuse and recycling conserve on materials so resources aren't depleted so fast; they also reduce the amount of material going to the sanitary landfill so it doesn't fill up as fast. Also, in many cases they conserve energy. It requires less than 5% as much energy to produce aluminum metal for manufacturing from waste aluminum than to produce it from ore.

Have the students investigate to see if there are any reuse or recycling programs in your community. Would others be feasible? You may want to organize a class project to assist a reuse or recycling effort or to start a new one.

5. Many other educational activities using trash and garbage are described in Schatz and Schatz (1971).

Statement of Concepts

See Statement of Concepts in Module 27.

The decomposers in the soil that recycle nutrients include fungi such as molds and mushrooms, bacteria, yeasts, protozoa, and small animals. The body of a fungus is usually composed of small thread-like filaments (hyphae) of cells. The network of hyphae is called a mycelium (pl. mycelia). Most fungi reproduce by spores, small one-celled reproductive bodies, that are usually carried in the wind and germinate into a new mycelium. Some spores are formed in rather complicated reproductive structures called mushrooms. The spore-forming structures of molds are much simpler.

Matter flow in the prairie is rhythmic or cyclic. However, many patterns of matter use and flow in our communities are linear from a resource to a dump. Linear flow results in change, often detrimental, as the resource gets depleted and the dump gets filled. There are cyclic patterns that can be substituted for some of the linear ones--such as composting, reuse, and recycling.

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Dwight Platt

Module 43: Preservation of a sample of the prairie ecosystem

Age level: High school

Subjects: Biology and Social science

Theme: Diversity

Sequence: Post-field trip

Following: Modules 12, 13, 16, 18, 19, 21, 22, 23, 28, 29, 30, 36, 37, or 41

Objectives: To explore the political, social, economic, and biological issues in a proposal to preserve a large sample of the tallgrass prairie ecosystem in a national park; to encourage students to be concerned about the preservation of the prairie

Time required: Minimum of 2 hours, but more time can be profitably used

Materials required:

Save the Prairie, a role-playing simulation of a congressional hearing (available from Save the Tallgrass Prairie, Inc., or available on loan from SKEEC)

Activities

1. Save the Prairie is a role-playing simulation of a congressional hearing on a proposal to create a Tallgrass Prairie National Park in the Flint Hills of Kansas. Before using this simulation with your class, read the introductory material on pages 4 and 5 carefully. Then read through the rest of the materials. Determine any modifications which will be necessary to fit the time available and your situation.

2. Before using this simulation, you may want to write to: Save the Tallgrass Prairie, Inc., 4101 West 54th Terrace, Shawnee Mission, Kansas 66205, to obtain more literature and materials favorable to the park proposal, and to: Kansas Grassroots Association, Inc., Box 186, Manhattan, Kansas 66502, to obtain more literature and materials in opposition to the park proposal.

3. Briefly review with the class what they learned on their field trip to Sand Prairie Reservation. Ask them how Sand Prairie Reservation is similar to and different from the prairie that was here when the European settlers first arrived. Would it be interesting to visit a larger sample of prairie where there are bison and elk and a more complete prairie ecosystem?

4. Read to the class the "History of the Prairie Park Movement" on page 5 of Save the Prairie. Discuss with them the procedure for establishing a national park. Be sure that they understand the way a bill goes through Congress and the function of a committee hearing.

5. Suggest that the class do a simulation of a committee hearing on a bill to establish a Tallgrass Prairie Park. Discuss the rules and the time to be allowed for the hearing. Decide how many and which witnesses and congressmen will be included and assign roles to students. Give each student the background materials (from Save the Prairie) to read that will help him/her to understand the role he/she is going to play. Literature favorable to and in opposition to the park proposal can be made available. Give students some time to study and plan their roles.

6. Do the simulation. After the simulation, discuss the questions on the bottom of page 4 of Save the Prairie or other questions raised by the simulation.

7. Have each student write a list of the strongest arguments for the park and the strongest arguments against the park that were raised in the hearing. Have them evaluate these arguments and indicate how they would reach a decision if they had to vote on this proposal.

Robert Regier

Module 44: Creating structural patterns

Age level: Junior high

Subject: Art **Theme:** Diversity

Sequence: Post-field trip **Following:** Module 29; also Modules 12 or 26

Objectives: To use structural patterns in nature as a visual resource for creative expression, thereby discovering that awareness of structural diversity can expand creative possibilities; to develop greater awareness of the many structural parallels in art and nature in one's own visual expression and in the work of other artists

Best time of year: This module could be introduced at any time; however, it would be best to introduce it immediately following the field trip experience in Module 29

Time required: A minimum of two sessions (activity could extend considerably beyond two sessions depending on interest and the number of activity options introduced)

Materials required:

Slide set #12: "Creating Structural Patterns"
Drawing paper
Pencils
Rulers
Small brushes
India ink
Pens and pen holders
Black construction paper (9" X 12")
White construction paper (12" X 18")
Colored marker sets and/or tempera colors
Scissors

For optional Step 5:
- 3" X 5" linoleum blocks
- Carbon paper or graphite transfer paper
- Linoleum block cutting tools
- Piece of glass (9" X 12" or larger)
- Brayer
- Water-based block printing inks (at least two colors)
- Oil-based block printing ink (if blocks are printed on cloth)
- Construction paper or rice paper
- Small block printing press, if available
- Tablespoons or teaspoons

For optional Step 6:
- Toothpicks, 1/8" dowels, or balsa sticks
- Small saw or knife for cutting dowels and sticks
- Model glue for wood
- Spray paint (white or black)
- Tissue paper
- String

Investigation

The activity. To create an all-over pattern based on one or two of the structural patterns observed in nature, have the students use the following procedure.

Procedure.

Step 1

Select a drawing or one of the collected forms from the field trip as a reference point for the design. If the field trip module was not used, pictures or natural forms collected in Module 9, Activity, Part II could be used. Make several line drawings that describe the structure of the natural form, but avoid drawing contours or other parts of the form if they are not pertinent to an analysis of the structural pattern. Experiment with thinner and thicker lines, simple and complex variations; use pencil, brush, pen, or cut paper. Choose the most satisfactory design from the experimentation. It should not closely resemble the appearance of the object from which it was derived, but should reveal the object's structural organization.

Step 2

Experiment with ways that the design unit developed in Step 1 can be repeated. Consider overlappings or tangents, but have each repeated unit touch its neighboring units in some way. Also consider size and directional changes. After exploring these variations, work out a repeat pattern in pencil on a 12" X 18" sheet of construction paper. Fill the entire page, from edge to edge, with the pattern.

Step 3

Work out a color scheme for the design and complete the design in color, remembering that additional effectiveness can be achieved if as much attention is paid to the negative spaces (generally called background) as to the positive shapes. Either markers or tempera colors could be used for this step.

Step 4 (optional)

Select a natural form that has a different structural pattern than the one used in Step 1. Try developing a design that uses the pattern in combination with the pattern used in Step 1. Various groupings, alternating schemes, or super-imposed shapes could be considered. Follow the same procedures outlined in Steps 1, 2, and 3.

Step 5 (optional)

A whole new range of visual possibilities opens up if the design units in Steps 1 and 4 are traced on to separate linoleum blocks and cut out with linoleum cutters in preparation for relief printing. When cutting, remember that the negative areas need not be cut thoroughly clean. Uncut ridges that remain can produce printed textures that appropriately express the nature of the material and medium. After the blocks are cut, experiment with printing them in different combinations until a satisfactory pattern is developed. Each block should be inked in a different color. If one would wish to pursue this option further, the final expression could be in the form of a fabric design. A suitable piece of cloth should be marked off in pencil so that the blocks can be accurately located when printed. Oil-based ink, rather than water-based ink, should be used when printing on cloth. Rather than spoon rubbing or using a small press, the cloth can be placed on the floor over newspaper padding and printed by standing on the blocks with a slight rocking motion of the foot that is placed on the block.

Step 6 (optional)

Construct a three-dimensional version of the structure used in either Step 1 or Step 4. Depending on scale desired, either toothpicks, 1/8" dowels, or balsa sticks could be used. Modeling glue for wood would be the most suitable bonding agent because of its fast-drying properties. When building a three-dimensional structure, remember to view its progress constantly from all sides. It is important that it is visually effective from every viewpoint, and not just from one or two sides. The finished construction could be spray painted white or black to give it an additional sense of unity. A further step could be taken by adding "skin" to the linear structure. This could be done by using tissue paper to construct surfaces between various structural elements, or by spanning spaces with string. The same wood model glue could be used for either of these options.

Further activity. The visual activity just described represents only a few of the many possibilities that could grow out of the observations and research done in Modules 9 and 29. You should be free to explore other possibilities that would enable students to use their observations of nature as a basis for creative activity. Activity that springs directly from environmental observation is one method of discouraging visual cliches and stimulating fresh visual experience.

The principle of "variety within unity" (see Statement of Concepts, Module 9) could be applied to the completed designs of the students in the context of a group discussion. How are they unified? What gives them variety? Are some more interesting than others? Why? The group could be reminded once more that the principle that gives their work unity and interest is the same principle that is found in abundance in undisturbed nature.

If there is access to art and architecture slides, some of these could be projected for class discussion and analysis for the purpose of discovering how various artists have used structural ideas that parallel natural structures.

If display areas are available, it would be good to explore the possibility of sharing the results of Module 44 with a larger audience. If this is done, attention should be given to adequate labeling and commentary so that the display has an educational as well as an aesthetic function.

NOTE: Slide set #12, "Creating Structural Patterns," provides examples of some of the possibilities in this module. This set is intended as a resource for the leader. It could also be shared with the students if you feel it would help to stimulate interest and motivation.

Statement of Concepts

Review the comments on structure under Statement of Concepts in Module 9. It is important that the creative work in this module focuses on developing forms that parallel nature, not forms that copy or imitate nature. Stated in another way, the created forms should embody a structural pattern in nature within its own structure, but need not look like or represent the natural form that served as inspiration. Making an image based on natural form without illustrating the form being observed is the primary meaning of the word "abstraction."

Robert Regier

Module 45: Expressing the rhythms of the prairie

Age level: Junior high

Subject: Art **Theme:** Rhythms

Sequence: Post-field trip **Following:** Module 30; also Modules 7, 8, 12, or 14

Objective: To use the natural prairie as a subject for visual expression with special emphasis on its rhythms as a dominant compositional feature

Best time of year: This module could be introduced at any time; however, it would be best to introduce it immediately following the field trip experience in Module 30

Time required: A minimum of two sessions (activity could extend beyond two sessions depending on depth of involvement by leader and group)

Materials required:

12" X 18" construction paper or other heavy paper
A color media, such as crayons, markers, or tempera paint
Pencils
Art gum (kneaded) or soft rubber erasers
Brushes (if tempera paints are used)
White drawing paper

Investigation

The activity. The purpose of the activity is to design a landscape which expresses a number of rhythms, both large and small, that are visible within the environment of the natural prairie. Have the students use the following procedure.

Procedure.

Step 1

Every student should list a number of forms that contained rhythms which were of particular interest. After listing them, the student should sketch each one without concern for how they might be organized in one composition. Both large and small forms should be kept in mind--from seeds, flowers, and grasses to rhythmic hills and tree forms.

Step 2

Begin to organize the sketches by tracing or drawing them freehand on a 12" X 18" sheet of white paper. The organization can have a more conventional landscape appearance; e.g., fore-distance, middle-distance, and far-distance with the smallest objects of rhythm in the foreground, or it can have a montage appearance with rhythmic forms related to each other according to compatible shapes and movements, etc. rather than logical landscape appearances.

Step 3

Complete the composition in color, using crayons, markers, or tempera paints. As the composition grows toward completion, be sure that the rhythmic qualities of the forms are not lost or weakened. This can be assured if there is a constant reminder to keep the rhythmic aspects of all forms visually stronger than any other aspects such as descriptive contour, texture, and unrhythmic details or decoration. Careful decisions about contrasting colors or values and thicker or thinner lines where appropriate will help keep the visual rhythms clear and strong.

Further activity. Display the results so that the group can appreciate the diversity and individuality of the paintings and share them with a wider audience.

You should be free to design other visual problems based on rhythm to supplement the activity in this module. Any two- or three-dimensional media accessible to the class and familiar to you could be used.

Another variation, somewhat more complex, would be to have the group focus on rhythmic movements rather than forms that have rhythmic arrangements. How would one express the rhythm of wind blowing through tall grasses, or the rhythm of a bird in flight?

Statement of Concepts

Review the discussion on rhythm in Module 10.

The creative activity in this module is an exercise in abstraction. Abstraction in art is often a very vague concept. The popular conception of abstraction is that it refers to images that seem disorganized and without recognizable subject matter. Another popular usage is that all art which is not realistic, which does not look exactly like the objects it portrays, is abstract. If such a definition is used, all art is abstract because it is virtually impossible to copy nature in all its detail.

Abstraction is the art process by which the artist proceeds from a perception to the delineation of that perception through his use of art materials and techniques. So the look of an art object depends on which perception or set of perceptions operated most strongly in the eye and mind of the artist. Artists may be looking at the same subject but bring varying perceptions to it. This accounts for the wide range of interpretations of a given subject. When perceptions other than a concern for careful, complete optical description are brought to a subject, the result is an abstraction. A certain aspect of the subject is of more interest or concern than other aspects, and so that aspect is "abstracted" from the subject.

In this module the aspect of rhythm is the core of the perception that is is brought to nature. Therefore, the resultant image each person creates should deliver the perception of rhythm to the viewer, even if this means other valid perceptions are ignored or subordinated for the sake of rhythm. Rhythm, consequently, becomes exaggerated, but this is the artist's way of making the invisible visible. The "message" of this activity is to create an awareness of rhythm. This can only be done through emphasis and exaggeration even if a conventional view of reality is distorted in the process of making the message clear.

Emphasizing rhythm at the expense of other visual perceptions draws the group into a process basic to almost all art. One could approach a variety of art by asking which perception seems to be of most interest to the artist? The answer could be light, color, emotion, texture, order, action, or many other things. The answer for the landscape creations the group produces should emphatically be rhythm. Slides 26 and 27 in slide set #6, "Rhythms in Art and the Environment," illustrate two landscape interpretations that reflect the artist's interests in rhythmic relationships.

The biologist is sensitive to rhythmic patterns because he sees them as essential to many of the life processes on the prairie. The artist is sensitive to rhythm because it is a source of aesthetic satisfaction and unity, whether it be the visible rhythms of the prairie, rhythms in man-made objects, or rhythms in art.

Howard Snider

Module 46: The radial effects of social events

Age level: High school

Subject: Social science **Theme:** Interdependence

Sequence: Post-field trip **Following:** Modules 16, 25, 36, 41 or 42

Investigation and Observation

An investigation of the phenomenon of interdependence can be made from many points in the network of social relationships.

Part I. Divide the class into working groups of 3 or 4 persons each. Assign to each group the task of tracing the effect of an incident through different levels of society. Have them outline some of the factors in society that would modify these effects. How would these change in other cultures? (See illustration in Statement of Concepts). Then have each group report to the class and let the class discuss their analysis.

1. Event: A football star breaks his leg

   Task: Trace the effects through three levels of society:
   A. Primary - the team and family
   B. Secondary - the school
   C. Tertiary - the larger community

2. Event: Birth of a child

   Task: Trace the effects through three levels of society:
   A. Primary - parents and siblings
   B. Secondary - close relatives and friends
   C. Tertiary - the larger community

3. Other social events which might be analyzed in relation to radial effects:

   A. Any rite of passage and the social role changes related thereto:
      Death
      Marriage
      Job promotion
      Retirement, etc.

   B. Any modification of status:

      Downward status change: Illness or accident
      Demotion
      Loss of job
      Failure

      Upward status change: Graduation from college
      Development of skill
      Any success
      Fortune - inherited wealth, position

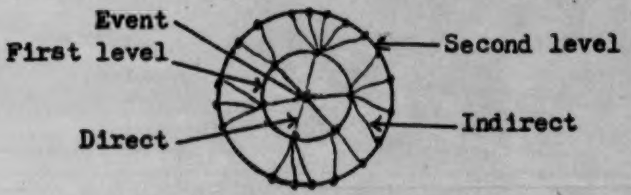
Part II. Play Risk, Monopoly, Ghetto, or another group game of this type. Each person in the group should keep a record of his/her moves or actions. After a period of time, stop the game and have the group analyze the impact of each event on subsequent events in terms of closing and opening other possibilities. Note what options are closed and what options are opened.

Statement of Concepts

Human events, as all events, are interconnected. Actions cannot occur in isolation. The actions of one individual or group have a sequence of consequences which may be traced through other individuals and groups, and through time. The pattern of social events is much like the following physical illustrations:

1. Object striking a web
2. Pebble in the pool
3. Effect of a chemical on ecological balance

1. Events have both direct and indirect effects.

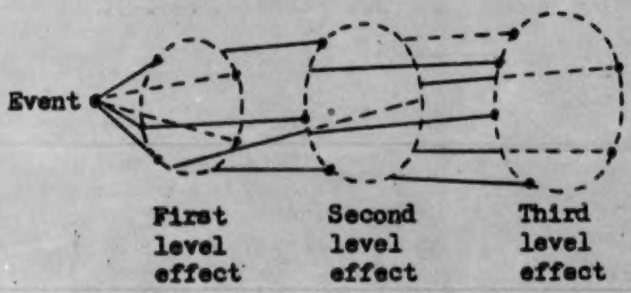

Event
First level
Second level
Indirect
Direct

Web-like effect of events

2. Each person is at a point in a great web of relationships. An event at one point affects events at every other point:

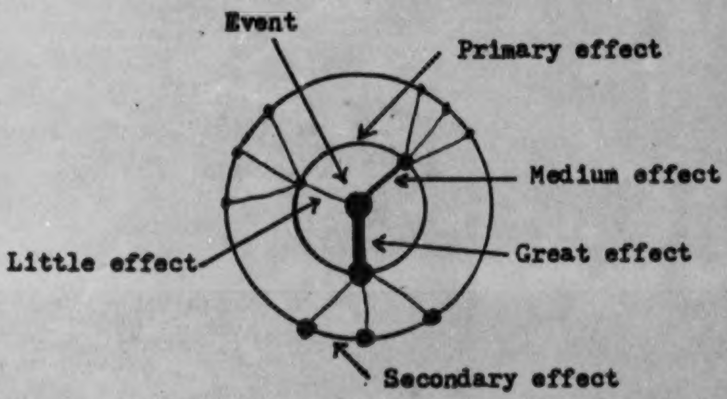
   A. An event close by is intense in its impact.

   B. The farther away the event, the less its impact.


Event
First level effect
Second level effect
Third level effect

Event impact stretches social relations

3. Filaments of interconnections are all interconnected but different. There are differential effects in different directions depending upon strength and intensity of ties. The number of connections and interconnections of social groups are manifold.


Event
Primary effect
Medium effect
Little effect
Great effect
Secondary effect

Differential effects of events dependent on proximity and intensity of connection

4. The closer to the center, the greater is the impact throughout the whole structure of the interactional web. There are effects at primary, secondary, and tertiary levels.

The following is an illustration of a sample expansion illustrating the radial effects of the birth of a child:

A. Effects on different levels (this natural event impinges widely):

1) Primary level effect:

Parental roles are modified radically (How?)

- Working mother stops working
- Social life changes, e.g., patterns of entertainment
- Household scheduling changes, e.g., sleeping
- Priorities of activities are modified
- Pressure on economics (how?)

Siblings are affected (how?)

- Competition for needs: Affection
  Time
- Scheduling: Time

2) Secondary level effects

Impact on immediate close relatives and friends (how?)

- Gifts
- Adoption of an additional affective dependent
- Schedule
- Obligation to the family

3) Tertiary level effects

Community effects (what and how?)

Immediate: Medical services
Resources for food, clothing, toys

Long range: New child becomes a factor in planning facilities:
Schools
Parks
Work opportunities

Sex of a child has impact on sex ratios:
Marriage market

Economic aspects:
Worker

B. Factors related to radial effects:

1) Social class of family (how?)

	High	Low
Economic	Retail sales increase	Welfare costs increase
	General economy benefits	General economy strained
Education	Modified prospects for high schools and colleges	Modified prospects for trade schools
	Teachers	Teachers
	Facilities	Facilities
Religious	Church possibilities	Sect possibilities

(Other institutions could be included)

2) Location of the events

Rural	Urban
Rural south, U.S.A.	Metropolitan N.E.
Rural central	Urban central

3) Size of immediate group

Small family	Extended family
Nuclear family	Commune

4) Social position of the event (what is the effect of differential birth position on life changes?)

Powerful
Weak
Prestigious
Low status

5) Nature of the affective relationships

Families and cultures vary in the degree and nature of affective attachments

6) Variations of cultural values related to communal and interpersonal responsibility

Individualism vs. community and interpersonal responsibility

7) Nature of the hospital institution in the economic sector

Socialistic medical system vs. private enterprise medical system

Howard Snider

Module 47: Cyclical and rhythmic nature of social phenomena

Age level: High school

Subject: Social science　　**Theme:** Rhythms

Sequence: Post-field trip　　**Following:** Modules 28, 30, 40, 42, or 45

Objectives: To become aware of rhythm in social events and to understand the social meaning of recurrent events

Materials required: None

Investigation

Divide the class into four groups and let each group work with one of the following activities:

Activity 1, The daily cycle. Have each student keep a log of events through a number of days, i.e., a schedule of all they do in fine detail:

physical preparation for the day
meals
work events } alone
play events } with friends
with group

After several days of observation and record keeping, ask the students to locate from the data the elements of regularity and regular sequences of events.

Activity 2, The weekly cycle. Have each student keep a log of events for a week:

class schedules
events which occur each week
weekend schedule

They should list the activities which are routine and those which are special for the week. Have them keep a careful diary of one event which recurs on a weekly basis in terms of regular behavior patterns and regular emotional responses.

The listing of special events of a week should include people involved, schedule, order of activities of both individual and the group. Do this for each of the phases of the special weekly events:

anticipation
event
post-event activities

Review the event in terms of emotional response in respect to each phase. This should include emotions related to expectation: pleasure, joy, anxiety, boredom, excitement, fear, etc.

Activity 3, The annual cycle. Have the group list the sequence of festival events through the year:

- New Year's
- Valentine's Day
- Easter
- 4th of July
- Thanksgiving
- Christmas, etc.

The group should then select one particular event and assess its phases (anticipation, event, post-event activities) for both action and emotional elements. Look particularly for the regularity of the events related to each festival in individual family groups, e.g., what traditions has each family represented in the group developed for each of these festival events?

Activity 4, The life cycle. Have students individually and as a group recall and discuss the occurrence of rites of passage events as they perceive and recall them in their parents' lives and as they observe and anticipate them in their lives:

- birth
- going to school
    - kindergarten
    - junior high
    - senior high
    - college
    - graduation
- first job
- beginning of dating
- engagement
- marriage
- buying house
- regular job
- birth of children
- first child to school
- last child to school
- first child leaves home
- last child leaves home

Have each student in the group gather data on generational cycles and a specific event, e.g., have students obtain interviews with grandparents, parents, and married siblings about the events surrounding their weddings. They should be concerned particularly about events and feelings which occurred with these rites widely separated by time. They should note both similarities and differences.

Discussion. Have each group report to the class on their work. After each report, discuss the nature of cyclical aspects of social life in order to note similarities and differences regardless of whether the event occurs weekly or once in a lifetime. Use the following points (wherever relevant) as a basis for discussion:

1. Identify: beginning activities, transitional activities, end activities } i.e. What starts a cyclical event? What keeps it going? What causes it to stop?

   Note how these are scheduled in terms of: time
   other activities

2. Identify the underlying meaning which relates a cyclical event to similar past and future events, i.e., what is it that is common to all, not only in repetition of behavior, but also in meaning?

3. Identify the aspects of the event that are individualistic and the aspects that are communal.

4. Identify what cycliceal events do: for the past } for the individual
for the future} for the social group

5. Note the participants in the social events:

    Who is involved?
    How large is the group?
    What changes in the group occur over time?
    What is the relation of the size of the group to the event?
    What kinds of people celebrate specific events?

6. Discuss the relative public nature of different events.

7. What is the relationship between the public nature of cyclical events and their importance for society?

Statement of Concepts

No events in social phenomena recur in identical form. But events do recur in modified form with amazing frequency.

Each such event takes form and meaning from the preceding similar event. The event is similar enough to recognize the species but differs in time and specific content. Each such cyclical event recalls something of the past and predicts something of the future. Thus, any social phenomena in a cyclical sequence is an element in the continuity of any human culture.

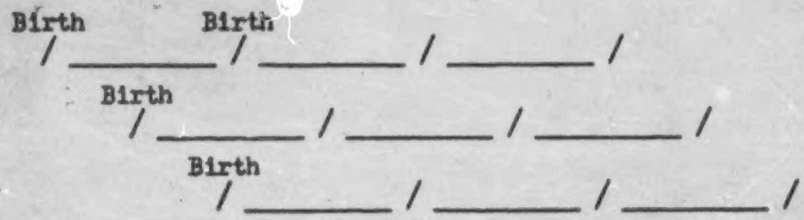
These rhythmic cyclical human phenomena occur in a wide variety of patterns. Some events are related to others in simple repetitive patterns as are the days of the week or weeks of the year: / / / / / etc.

Similarly, seasons of the year follow one another year after year in a cyclical pattern. Such repetitive patterns in social events bring order, but they also may bring boredom. With a little more observation, however, it is clear that very few repetitive events occur in the social world. There tend rather to be cycles of events in which the routine of regular events is broken by less frequent or irregular events.

Such cyclic events occur with regularity but low frequency in a pattern, such as a birthday celebration or other annual calendrical events occurring once a year (for example, special festival events marking seasonal activity in agrarian societies): / _____ / _____ / _____ /

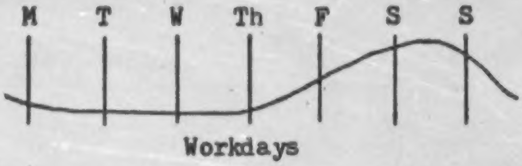
The generational cycle likewise represents this regularity of events in the birth of one generation leading to the birth of another generation. The occurrence of such patterns makes possible the existence of an individual and of a genetic line through generations. The overlapping of such patterns of regularity makes possible the existence of society.

"Men may come
and men may go,
but I go on
forever."
- society


Birth
Birth
Birth
Birth

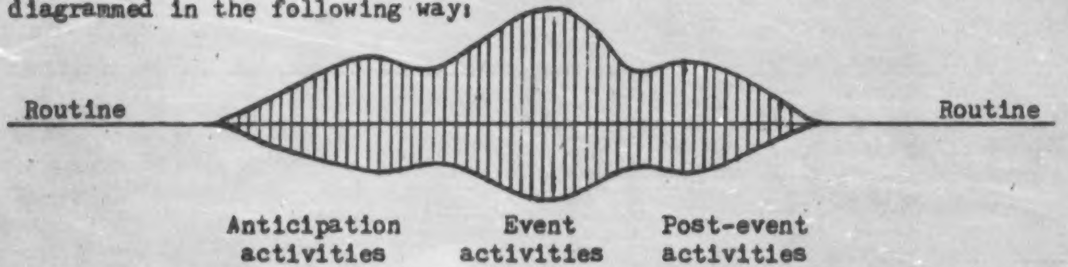
The pace of events may vary calendrically and seasonally in terms of intensity of both activity and meaning. Preliminary activity, festival activity, and post-festival activity combine to represent this cyclical and modulated character of social phenomena. This may be illustrated in the anticipation of the Christmas festival, the increased tempo of activities, the climactic celebrative events of the family tradition associated with the event, and the post-celebrative events associated with cleaning up, storing gifts, and returning to normal work routines.

This may be observed further in a weekly cycle of events which for many may consist of five workdays and a weekend. The weekend events serve to break the relatively slow social activity of the workdays.

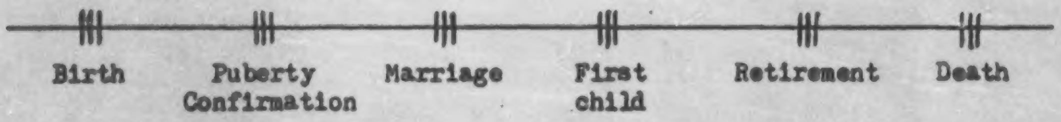

M
T
W
Th
F
S
S
Workdays

Those whose principal weekend activity is related to religious activity may find social anticipation realized particularly in the specific religiously-related social activity.

The phase or modulated character of cyclical social activity is more pronounced in those events which regularly occur but are widely separated in time, particularly those that are annual in nature, such as Christmas, Easter, and birthdays. The rise and fall of social activities may be diagrammed in the following way:


Routine
Routine
Anticipation activities
Event activities
Post-event activities

The life cycle of an individual consists of a sequence of events, such as rites of passage. These rites of passage are non-recurring as far as an individual is concerned. They occur relatively infrequently, but because of their "once in a lifetime" character and the social significance of the event, they are marked by unusually intense levels of celebrative action and emotion.


Birth
Puberty Confirmation
Marriage
First child
Retirement
Death

Howard Snider

Module 48: Similarity and diversity in social institutions and events

Age level: High school

Subject: Social science **Theme:** Diversity

Sequence: Post-field trip **Following:** Modules 13, 18, 19, 21, 23, 26, 29, 33, or 44

Objective: To become aware of similarities and differences in human social patterns and the relation of these patterns of similarity to stability in individual, group, and societal life

Materials required: None

Investigation

Activity 1, Becoming aware of similarity. Human societies all over the world are organized into subgroups called families. The family is a cultural universal. Although the forms of families may be quite different, they perform essentially the same functions and are therefore similar social phenomena.

Discuss with the class what families do for: the individual
the group
the society as a whole

This may be done in response to the fundamental questions: What do people need? How does the family respond to and fulfill each of these needs?

Individual: physical care
emotional security
affective context
meaningful social interaction
ordered sexual need gratification

Group: order
control
predictability
regularity

Society: reproduction
skills
socialization into the values of society
social ordering

Activity 2, Becoming aware of differences. Although families all over the world are similar in the ways they function for the individual, the group, and society, the forms they take are exceedingly diverse (see Homans, 1950).

Divide the class into three groups. Have each group gather data with respect to some aspects of family living as they are expressed in one society: in an American family, a Chinese family, or a Tikopian family. Other cultural groupings may be substituted for these. They should find information on some of the following aspects of family life (select from the following list and assign the same aspects to each group working on families in a different society):

courtship system

marriage festival events

residency patterns

social relations with in-laws

roles: sex roles } i.e., what types of activities and work are
age roles } appropriate for each sex and each age group?

child rearing patterns: toilet training
discipline
methods of informal and formal training in the values of the community

children's relationships to kinfolk: to maternal siblings
to paternal siblings
to cousins

After the groups have completed their assignments, discuss with the class the aspects of family living that have been assigned. Have each group report on their findings for each aspect of family living and write the information on the chalkboard in a table of the following type:

Variable	American Family	Chinese Family	Tikopian Family
Courtship system			
Marriage festival events			
Residency patterns			
Social relations with in-laws			
Etc.			

Discuss the differences and similarities in these families.

Activity 3. Differences between families within a culture. Ask each student to compare his/her own family with the family of a friend or neighbor. This can be a written assignment. Items to be considered can be selected from the following:

number of children
marriage age
difference in sex role emphasis
patterns of discipline of children
variations in permissiveness
housing patterns
relation to grandparents
entertainment patterns
punctuality
authority roles
values
recreational activities

Activity 4, Differences and similarities in festivals. Many things which at first glance seem very different have many elements of similarity that make it possible to include them within the same general class. In the following activities, progress from an analysis of diversity to an analysis of similarity. Select a number of common annual festivals and discuss their differences and similarities with the class.

1. In a table such as the following, on the chalkboard list the differences suggested by the students:

Christmas	4th of July	Thanksgiving

2. In a similar table, list the similarities.

3. Discuss the nature of the similarities in these festivals in terms of:
    - general activities (kinds and modes of activities)
    - emotional experience
    - people involved

4. Discuss the nature of festival ("festival" used as a general term).

5. Discuss the function of festivals:
    - What do they do for people?
    - What do they do for the group that participates together?
    - What do they do for society?

Point out to the class that social phenomena, like any other phenomena in nature, have similarities and differences. These similarities serve to give structure to life; differences provide diversity. Similarities create an order of events that make expectations and anticipations possible. Thus, events are to a large extent predictable. These ordered predictable events are necessary for stability for individual, group, and society as a whole. It is likely that the majority of life activities are simply repetitions of previous events with only slight modifications and variation.

Activity 5. The infrequency of the unique. Divide the class into two teams. Have one team try to isolate unique events and the other team attempt to show similarities with other similar events.

Statement of Concepts

Repetition in nature. Even cursory observation in nature indicates a great deal of repetition of things and of events, e.g., members of a genus repeat characteristics of the genus; members of a species repeat even more characteristics. Further examples may be found in the sameness of offspring through thousands of years and the resemblances of people of the same family group.

Similarity. Things and events with common identifiable characteristics are said to be similar. These commonalities lie at the basis of categorization and classification. Although no two things are absolutely identical in nature, enough commonness exists between some things to perceive them as belonging to the same class of phenomenon. In the social world, classes of social phenomena may be present. For example, one class is a social structure known as the "family" although the form of the family may differ from society to society. Likewise, there are structures for production and exchange of goods in an economic system. Although the variations may be great as, for example, between a technological society and a simple pastoral society, the economic structures present in each society function to meet the physical and cultural survival needs of both kinds of society.

Difference. Although many things have similarity enough to be grouped together, they may differ sufficiently to make one aware of subgroupings. In the social world these may be considered as performing the same function but have different forms.

Uniqueness. Although elements of events or behavior, such as those associated with a Christmas festival, may have the same general pattern, each Christmas season has its unique elements so that it is, in fact, different from all other Christmas experiences either past or future.

References

1. Homans, George C. 1950. The family in Tikopia. The Human Group. New York: Harcourt, Brace and World, pp. 190-229.

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Module 49: Interdependency and formal role networks

Age level: High school

Subject: Social science   Theme: Interdependence

Sequence: Post-field trip   Following: Modules 46, 47, and 48; also 16, 19, or 35

Objective: To become aware of the interrelations of roles and the nature of patterned interaction

Materials required: None

Activities

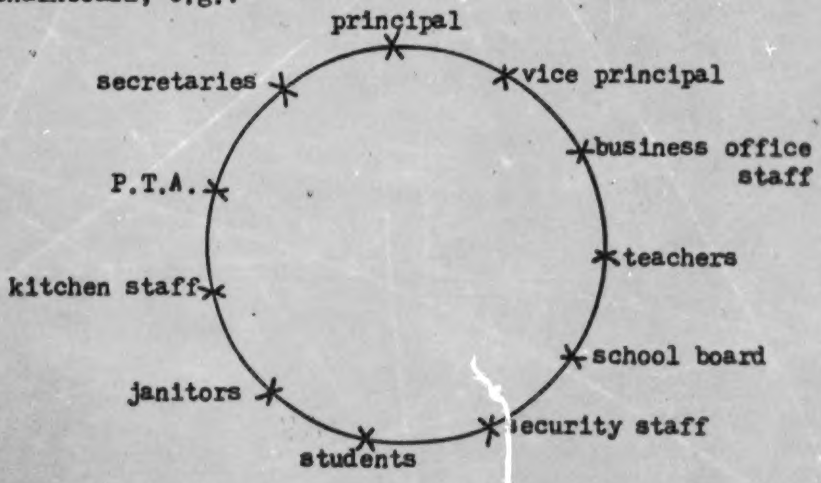
Activity 1, Becoming aware of roles. Have the students provide a list of occupations and vocations present in our society (see Occupational Outlook Handbook). Discuss briefly the functional contribution of each, i.e., what it does for:

the individual
the group
the society

Activity 2, Becoming aware of formal roles. Have each student select a different formal role and describe the activities associated with it. Have him/her write a report identifying the people who are affected by the role and elaborating in an exhaustive way the effect of the activity on each person associated with the action--both the initiator and the recipient of the action. These observations should be made with respect to:

the individual
the group
society as a whole

Activity 3, Roles within an institution. Select a specific example of an institution such as the students' own school. Have the students list all of the roles that exist. Make a diagram of these roles in a large circle on the chalkboard, e.g.:



Discuss the interdependency among these roles with the class. Draw lines between each with varying thicknesses to indicate the importance of the interdependency. For each relationship describe the nature of the dependency.

Select another less familiar institution and speculate on the roles and the relationships that exist.

As a variation of this activity, take a class trip to some other institution--a judicial institution such as a jail, or an economic institution such as a business or factory--and ask for a description of the organizational structure. Discuss with your informants the kinds of roles in their organization and the nature of interdependency.

Activity 4, The hierarchy of roles in role networks. In any network of roles some are more important than others for the survival of the network. A breakdown of some unimportant roles will not upset the working of the system to the extent that a breakdown of the more significant roles would. For example, the absence of a secretary will have less effect on a school than will the absence of a teacher. Select one of the institutions studied in Activity 3 and explicate the roles in that network of roles to the class; rank them according to their importance and provide a rationale for the order.

Discuss the following questions with the class:

What is the result of this kind of ranking?

How is ranking rewarded?

Is the hierarchy necessary?

What might happen if there were no difference in prestige?

Activity 5, Effect of changing roles on network relationships. One of the marked changes in the past decade is the increasing power of students in making school decisions. Discuss with the class: How does this change the role relationships? Consider this matter as it affects each of the relationships discussed in previous activities.

Activity 6, Institutional interdependence in societal functioning. Chart the interrelationships of a number of businesses and institutions. Consider the following particularly:

family
school
church
place of work

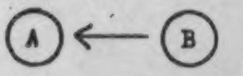
How do they affect one another?

Statement of Concepts

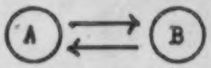
"No man lives to himself and no man dies to himself."

The quotation suggests that men are dependent and interdependent. What one does affects other people. Several crucial concepts related to these principles are described below.

Dependency. It is evident that nothing living can survive in total isolation. Even the most rudimentary organism is dependent on outside sources for sustenance. The physical human being has many needs which can be met only by outside resources. Food, shelter, and clothing are the obvious physical needs. Affection, acceptance, and esteem are the obvious emotional needs. These needs can only be met by resources in the external environment. All of these needs are supplied by other people and, in most cases, by the conjoint activity of other people. Each person and each group of persons needs other people and groups of people. Diagramatically this may be illustrated in that A receives from B whatever he needs to survive; A is thus dependent on B:



Interdependency. Individuals and groups ordinarily not only draw support in a dependent way from other individuals and groups, they also tend to give support to these same individuals and groups. Thus, a condition of interdependency is established. This interdependency may be illustrated and elaborated as follows:



Two-way action of giving and receiving is elaborated in the following specific ways:

A is able to survive because he gets from B

B is able to survive because he gets from A

A is able to survive because he gives to B (or someone else)

B is able to survive because he gives to A (or someone else)

This interdependency may be illustrated concretely by reference to a biological organism. In the animal world it is clear that the organs of the body, while each performing specific functions which aid the remainder of the organs of the body, are in turn dependent on other organs for their own survival and functioning. Thus, the heart pumps blood for the functioning of the lungs and the lungs in turn supply oxygen for the heart muscles so that they may continue to function.

Interdependency of individuals and groups within society is just as real but more complex than that of the physical interdependency illustrated in the physical body.

Role. What people do in a regular way for others is their role. There are formal and informal roles:

Formal roles: a job, a vocation, an activity which fills some need for others, e.g., teacher, banker, husband, student, etc.

Informal roles: people perform certain activities which meet certain needs of others which are not as clearly recognized as official or formal work roles. One may recognize these roles in such things as providing affection, providing leadership, providing support for leaders in informal situations, etc.

Network of roles. Regular activities of a number of people tend to mesh together in such a way that many things are accomplished which could not be accomplished alone. Each role supports and complements other roles and all the roles combine to accomplish a task.

References

1. U. S. Department of Labor, Bureau of Labor Statistics. 1974. Occupational Outlook Handbook, 1974-75.

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Module 50: Interdependency and informal role networks

Age level: High school

Subject: Social science **Theme:** Interdependence

Sequence: Post-field trip **Following:** Module 49; also Modules 16, 19, or 35

Objectives: To become aware of informal roles; to develop skill in describing the role; to become aware of the functions which informal roles play

Materials required:
Data sheets (Supplement #1) - one copy per student

Activities

Activity 1, Becoming aware of informal roles. Have students consider roles within informal groups, particularly the primary grouping with which they are intimately involved, such as a friendship group or clique.

Identify those activities in a group which are not formally prescribed but which are performed by someone, e.g., each primary group has a leader and followers. It is likely that the leadership changes somewhat depending upon the task. Some tend to ask questions; others clarify issues. Some add to tension; others relieve tension. Ordinarily informal roles tend to have larger components of emotional functions than formal roles.

Have the students suggest informal roles in a group and list them on the chalkboard. A list of informal roles might include the following as well as others:

Who has ideas for group activities?
Who supplies ideas for variation?
Who is the wet blanket?
Who provides supportive enthusiasm?
Who provides the lighter touch?
Who keeps activities on practical levels (the realist)?

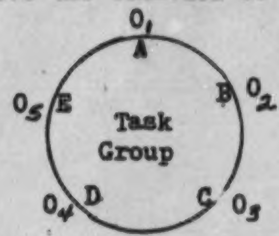
In order to become aware of informal roles, it is necessary to go beyond the name to a description of the behavior. Describe the behavior in detail and attach descriptive labels to each of these patterns of behavior as they are suggested. (Note "the realist" in the last of the above list). Many other functions should be added to this list.

Activity 2, Informal roles in formal situations. Use Bales Interactional Analysis Paradigm to observe the informal roles that occur in a formal task-oriented meeting.

Duplicate data sheets (one for each student) from the data sheet in Supplement #1.

Arrange for the class to attend, as silent observers, the meeting of a group engaged with a task. This could be a city commission, a committee, etc.

Assign specific students (O_1, O_2, etc.) to observe the behavior of specific persons in the task group (A, B, etc.).



Observations should be made relative to each of the categories on the data sheet and a notation made whenever a behavior occurs. For example, if O_5, who is observing E, notes that E asks for an opinion from B, a "B" should be entered in one of the spaces opposite the category of behavior observed. In cases where the action of E is not focused on a particular person, a notation of "Gen" might be entered to signify a general unfocused action. This record of E's behavior will give a composite picture of the activity of E by adding the actions in the horizontal rows. The general types of action expressed by E and the focus of his actions will then be clear. After each observer has completed his observation, a composite record may be made of all the actions of all the members of the task group. The composite record may be analyzed to reveal the relative activity of each of the task members in each category, the persons toward whom most action was directed and the general tenor of the group activity as a whole.

The following additional questions are valuable for group discussion about the observations obtained by Bales interactional analysis:

> What is the effect of each kind of social action?
>
> What is the overall pattern of informal behavior of the group? (You may want to diagram this pattern on the chalkboard).
>
> What effect do these informal actions have on the overall task of the group?
>
> In what way does this meshing of informal roles reflect interdependency?

Activity 3. Informal roles and interdependency in the family. Very few roles are specifically outlined in the legal documents which form a marriage. This organization--the marriage and the family--has, however, many and complex role relationships. Some of the roles are explicitly stated and universally agreed upon in any culture. Then normative behaviors regulate the activities of individuals in the family as they interact with one another. In each family certain roles are worked out over time. These roles come to be the normal ways for interrelating, working, and living together in that family. In a limited number of activities in families, some degree of flexibility of roles is also experienced. Thus, there is a continuum of roles which range from that of expectation to that of great flexibility.

Have the students suggest a series of activities ordinarily performed by members of the family in the business of living together, including household chores, recreational activities, and social activities. List these suggestions on the chalkboard. Make the list as exhaustive as possible. Then have each student allocate these roles or activities to members of his/her own family and to one of the following three categories:

a. Role activities in families for father, mother, and children which are nearly universal within our culture.

b. Roles and role relationships which are unique to his/her own family.

c. Role relationships that change or are less fixed than a and b.

Discuss the roles that students have assigned to category a. How much agreement is there on these roles? What differences are there in the assignment of roles in categories b and c?

Statement of Concepts

Much of social interaction occurs in other than official and formal ways associated with work roles. People are constantly interacting with and responding to others in ways that are outside of formal work definitions. These ways of interacting tend to be laden with emotional content and are, therefore, related to such matters as satisfaction and happiness.

There are many gradations of informal roles. Some are expected and almost obligatory, as those interactions between parents and children; others are very indefinite and changeable, as the roles of individuals in friendship groups.

Regardless of how loosely defined roles may be, they do exist. The behavior of one individual or group does affect the behavior of other individuals and groups. Even unconscious behaviors tend to become regular and predictable and in this way they are role-like in their effects in a group.

Much of social life is held together by actions which are not recognized in organizational charts and which have no official names. Most of the time they are unrecognized except when one stops to analyze behavior. It is likely that all relationships between people become rather routine and the patterns so fixed that a close analysis will enable one to describe the relationship and name it. An illustration of an informal role is that of an individual in a friendship group who tends to provide leadership for group activities. The role of follower is also obvious in this context.

It is likely that social life would collapse and that even the formal roles of individuals in organizations would be impossible without the less obvious social roles which all individuals play.

References

1. Olmstead, Michael. 1959. Bales system of observational categories. The Small Group. New York: Random House, p. 123.

Module 50: Supplement #1

Bales System of Observational Categories

Person Observed_____

Types of General Roles		Action Directed Toward													Total
Social Emotional Area (positive)	Shows solidarity, gives help, reward														
	Shows tension release, jokes, laughs, shows satisfaction														
	Agrees, shows passive acceptance, understands, concurs, complies														
Task Area (neutral)	Gives suggestion, direction implying autonomy for others														
	Gives opinion, evaluation, analysis, expresses feeling, wish														
	Gives orientation, information, repeats, clarifies, confirms														
	Asks for orientation, information, repetition														
	Asks for opinion, evaluation, analysis														
	Asks for suggestion, direction, possible ways of action														
Social Emotional Area (negative)	Disagrees, shows passive rejection, formality, withholds help														
	Shows tension, asks for help, withdraws out of the field														
	Shows antagonism, deflates others' status, asserts self														

References

1. Olmstead, Michael. 1959. The Small Group. New York: Random House, p. 123.
2. Secord, Paul F. and Carl W. Bachman. 1974. Social Psychology. New York: McGraw Hill Book Co., p. 291.

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Module 51: The individual, institutions, and social structure

Age level: High school

Subject: Social science **Theme:** Interdependence

Sequence: Post-field trip **Following:** Modules 49 and 50

Objective: To understand the complex interrelated sets of roles that make society possible

Materials required: None

Activities

Activity 1, The patterns of interaction in the economic institution. Point out to the students that the economic institution is concerned essentially with the development and distribution of resources. Identify central organizations in the economic institution.

The economic institution of a complex modern society is comprised of at least the following organizations and systems:

- Banking system with its many units and branches
- Production system
  - Primary - agricultural, mining
  - Secondary - industrial
- Distribution system
  - Transportation
  - Wholesale and retail organizations

Discuss with the class the functions of each of these three segments of the economic institution. What does each do for the others?

Have the class study a local example of each of the above. Arrange to interview the president of a bank, a manufacturing establishment, a retail store, and a transportation company. Have the interviews at their places of business or have a meeting with all four together. Let them discuss the nature of the interdependency which exists and the ways in which their roles complement each other.

Activity 2, The economic institution across time and degrees of complexity. Plan a unit of study comparing the economic institution in our society with the economic institution in several simpler societies:

- American Indian society at the time of European settlement
- Early frontier farming community
- Farming community of 1920-30. (The grandparents of students might well supply information).

Particularly note the underlying similar functions of the activities of the economic institution as it relates to the basic survival problems of the society regardless of the time period (see Isely and Richards, 1944, 1961).

Activity 3, The religious institution. Although our society is religiously plural, religious groups in general have many purposes which are similar. Have each student interview a religious leader: a minister, rabbi, or priest. They should ask questions such as the following and record the answers:

What do you expect your religion to do for people?
What will it do for society?
What do religious people do for society that irreligious people do not do?
How is your religion similar to other religions or faiths?
What particular kinds of problems does religion respond to?
How does your religion view the state, i.e., what attitude does it take toward "rulers?"

Religion tends to be most obvious at certain problem times.

What are the times and occasions when people turn to religious activities?
Why do they do this?
What effect does it have?

Governmental persons in American society generally tend to make a point of religious affiliation and faith.

Of what value is this?

Discuss the answers to these questions with the class after the students have completed their interviews.

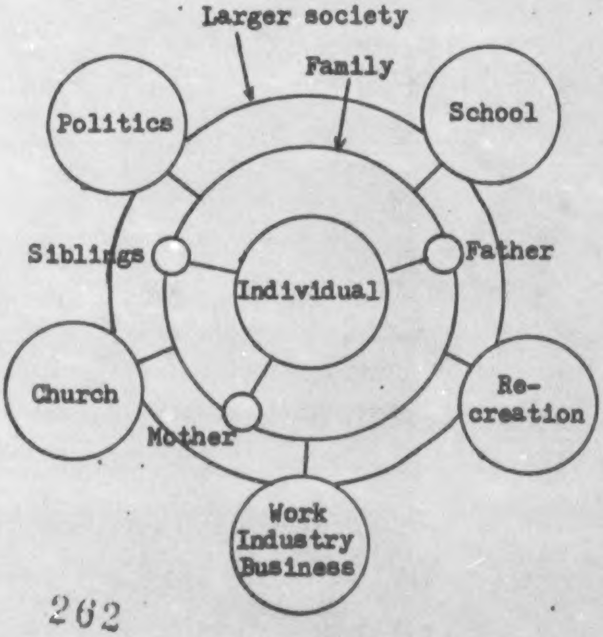
Activity 4, The place of science and technology among other institutions. Explain the use of technology in a simple society. Then discuss with the class the role of science and technology in society. How does simple technology compare with our complex technology?

Discuss the relationship between science and technology, i.e., the theoretical and practical.

How do science and technology affect other institutions, e.g., economics, religion, etc.?

Activity 5, The interdependency between the individual and the institution.

All of the people in a society bear some responsibility for all others.



People are connected to institutions through the same intermediate organization or local manifestation of the institution.

The diagram on the preceding page suggests the way in which the family unit ties the individual to the larger society.

Have the students discuss the ways in which the individual is connected with the societal institutions listed in the Statement of Concepts.

Statement of Concepts

Interaction between people develops patterns; as these ways of interacting become habitual, the social pattern becomes fixtured and structured. These patterned habitual structured ways of responding are necessary for individuals together to accomplish tasks which are impossible to achieve alone. If these tasks are crucial to the survival of society, the patterns of interaction related to these essential tasks are increasingly prescribed. They will be invested with value and deviation will be strongly punished. In all societies there are these crucial sets of complex interactions, i.e., structures, which enable the society to survive. These sets of complex regularized and routinized interactions are institutions. All societies tend to have the same institutions because they have the same basic problems, although these institutions may differ in form. The following are basic institutions which appear in some form or other in all societies:

Family
Economics
Education
Art
Science and technology
Politics
Religion
Law

A society, then, is really a set of interrelated sets of complex role relationships, all working together to accomplish the fundamental task of all societies--survival.

In previous modules the family particularly has been used as an illustration in order to understand interdependency, similarity and diversity, and other concepts. In this module an attempt should be made to perceive the roles and their interrelationships in other complex patterns.

References

1. Isely, Bliss and Walter Marvin Richards. 1944. Four Centuries in Kansas. Topeka: The State of Kansas.

2. Isely, Bliss and Walter Marvin Richards. 1961. Kansas Story. Oklahoma City: Harlow Publishing Corporation.

Howard Snider

Module 52: The unity of man and his environment

Age level: High school

Subject: Social science　　**Theme:** Interdependence

Sequence: Post-field trip　　**Following:** Modules 46, 47, 48, 49, 50, and 51; also 12, 16, 21, 22, 23, 36, 37, 39, or 43

Objective: To become aware that mankind is a natural part of nature and the environment

Materials required:

Film: "Home" (produced by the Southern Baptist Convention Radio and TV Commission)

Film: "Prairie Killers" (produced by National Educational Television)

Activities

Activity 1, Relation of mankind and his environment. Discuss with the class each of the possible relationships between man and his environment suggested in the Statement of Concepts. What evidence can be supplied to support each position? This activity may be pursued in research papers, a debate format, or simply open discussion. Historical evidence may be found for societies which have related to the land in each of these ways.

Activity 2, How does man fit in the natural environment? Take a field trip to Sand Prairie Natural History Reservation with an environmentalist or biologist. Have this person point out the numerous ways in which plants and animals interact with the soil and with one another to continue for generations. In what way is each dependent on the other? (If Modules 16 or 21 are used, the discussion can follow them).

A discussion following this field trip may raise questions such as the following:

In what ways do the plants and animals depend on the earth?
To what extent do they exploit the earth?
In what ways does man interact with the earth, water, and air like animals?
In what ways does man interact with these crucial aspects of his environment in ways different from other animals?
Why does man interact differently than animals?
Man lives in groups and is organized into societies. How does this affect the way he relates to the environment?
Man may have more social needs than some other animals. What might these be?
How do these needs and the unique nature of man affect his relationship to the environment?

Different groupings of people respond to and interact differently with the earth, air, and water. What differences might you note for each of the following groups:

primitive tribal group in a jungle area
hunting and gathering society
modern farmer
city dweller

The factors which may make for difference are principally technological systems and belief systems. How might these systems vary for each of these groups?

Activity 3. Man as a part of the natural environment. View the films, "Home" and "Prairie Killers."

Discuss the observations made by Chief Seattle concerning man's relation to land, air, and water. How do these positions differ from those of the white man in our industrial, technological society?

Activity 4. Measuring people's attitudes toward the environment. You are undoubtedly aware that in our society there are many different attitudes toward environmental problems and toward the use of earth resources. Have students interview a cross-section of people in the community to determine individual and group attitudes toward the use of earth resources. In order to measure these attitudes, develop items for a Likert-type scale. The following items are only suggestive; encourage students to develop their own.

1) Man is an animal and must relate to resources of the land and air as do other animals.	SA	A	U	D	SD
2) Nature is wild and must be controlled and dominated if men are to have a comfortable life.	SA	A	U	D	SD
3) Careful planning by some overall environmental protection agency is necessary if future generations are to have adequate resources.	SA	A	U	D	SD
4) Regardless of what men do to nature and the environment, nature and the environment are large enough that they will recover from damage.	SA	A	U	D	SD

SA: strongly agree
A: agree
U: undecided
D: disagree
SD: strongly disagree

Summarize the results of these interviews and discuss them with the class.

Statement of Concepts

Man is physically part of nature. Chemically he has everything in common with nature. He eats the same kinds of foods as do many other animals. The processes of his physical organism are similar to those of other animals. The atoms and molecules of the chemicals in his body function no differently than they do in any other place. The neural system of man is a set of highly complex electro-chemical networks. Man, thus, is very much physically a part of nature. He is made up of the same things as earth, air, and water. This unity of man with his environment raises many questions as to how man should relate to that environment.

In the film, "Home," Chief Seattle says, "Man belongs to the earth; the earth does not belong to man."

Man and nature can be perceived as related in three quite different ways:

1. Man can be seen as part of nature and simply cooperating with nature as a natural and integral part of it.

2. He may be seen, on the other hand, as in conflict with nature. The land and resources may be seen as foes to be subdued. If the land and its resources are seen as enemies, then either man or the land will finally be victorious.

3. A third position might view the land and natural resources as passive, simply existing to be exploited or left alone according to the decision of men.

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Module 53: Differential use of land by different social groups

Age level: High school

Subject: Social science Themes: Diversity and Interdependence

Sequence: Post-field trip Following: Module 52

Objectives: To understand how different societies on the prairie have related to the land; to understand that relationships to environment and use of resources is a result of a people's belief and technological systems

Materials required: None

Activities

Activity 1. Four societal patterns on the prairie. Become acquainted with the following four societal patterns of life as they relate to the prairie in Kansas:

American Indian hunting-and-gathering society

Frontier homestead subsistence society

Rural town farm family society

Industrial agri-business society of the present day

Acquaintance with the first two may be obtained by visits to museums, such as the Kauffman Museum at Bethel College, and to frontier home exhibits, such as the Adobe House in Hillsboro. A visit to and interview with a family running a small farm and a modern agri-business establishment are possible in most rural areas of Kansas.

On the visit to a museum, identify those artifacts related to each of the historic periods and ways of life. Have the students pay particular attention to those artifacts related to making a living from the land and the processing of food and other resources from the land. A visit to a modern mechanized farm will give a perspective on contemporary procedures. Have the students collect pictures which reflect each of the four modes of life.

Have the students use a table like the one in Supplement #1 to summarize the information they have collected on the way people related to the land. Discuss the way in which technological systems affected their relation to the land. Also discuss how the prairie environment affected the technology used.

Activity 2. Social institutions and the land. Have groups of students do an analysis of some institutional structure and its relation to the land in the four cultures and share findings with the class. Particular institutions which may be used are religion, education, science, recreation, etc.

The following outline relating to religion is suggestive for further discussion and investigation. Similar matrices may be developed to study the interrelationship between land and other institutions.

This activity enables one to see how specific aspects of living relate to the land in Kansas.

The Relation of Religion to the Land in Various Kansas Cultures

	Native	Frontier	Rural - Town Farm Family	Mechanized Agri-business
Deities: What do people believe about the way God relates to the soil, crops, animals, and weeds?	Local deities related to land and survival: physically culturally	Alien deities pitted against the wilderness: taming the wild	Imported deities and ideologies accommodated to rural agricultural base	Utilitarian deities and values which endorse utilitarian use of land
Group relation to the land: How do individuals relate to one another and to the land?	Tribal group	Individual	Community and ethnic or social group	Individual and national
Belief about the land	Land and its expressions are sacred	Land and wilderness is evil, chaotic	Land is capable of cooperating	Land can be controlled
Relation of people to the land	People are part of land	People against land	People work with land	People exploit land

Activity 3. Systems analysis of an institution. A very helpful way of making an analysis of social life is to use a systems analysis approach. The categories and column entries following would be a useful way, for example, to understand housing in relation to the land.

A Systems Analysis of Housing and the Land

Systems Concepts	Native	Frontier	Rural - Town Farm Family	Mechanized Agri-business
In-puts: What resources are available?	Local resources Manpower Cultural concepts traditional	Local resources Manpower Utilitarian Temporary	Imported resources Imported ideas of materials, structures, and forms	Imported resources Imported ideology and models based on other place and external resources
Through-puts: How are the raw material resources processed?	Functional processes Utilitarian	Utilitarian usage Expendable and readily replaceable	Modified in utilitarian ways	Processes for social status and shelter
Out-puts: What are the outcomes after resources have been processed?	Shelter Privacy	Shelter and maintenance of family	Shelter a base to work land and provide for family life and social life	Shelter a base to work the land and provide status
Homeostasis: How are needs, resources, through-puts, and out-puts kept in balance?	Each person builds own house of local materials, no over- or under-supply	Developed minimum housing for minimum needs with local materials	Developed functional houses for essential survival and social needs Modification to accomodate needs	Consumption-oriented structures Structural change for status maintenance
Feed-back effects	Immediate use Adequate, no surplus	Immediate use Adequate-inadequate cycle	Utilitarian use Surplus and shortage cycles	Utilitarian Surplus and shortage cycles
Diversity	Individual craftsmen Vary in size and decoration	Individually designed and constructed	Individually built according to general local design	Constructed according to external status standards
Cyclical: How long is the period from beginning to end of use?	Short	Short	Medium long	Long term

Activity 4, Beliefs, technological systems, institutions, and environment. Discuss with the class what impacts the various societal patterns have upon the prairie. What problems are created by each? Discuss the way in which beliefs, social institutions, technological systems, and environment interact.

Statement of Concepts

Different groupings of people live in different kinds of ways. They relate to the environment and to other groupings in different ways. Each group perceives that its way of living is the right way. Whether or not it is the right way may depend upon whether the society is able to relate well to its environment over long periods of time.

A society comes to have a belief in the rightness of its way of life and will tend to perpetuate its way of life. Members of the society move it with them when they move to a new territory. The way people relate to the environment determines in some measure the way they relate to each other and vice versa.

The United States in the last few hundred years has been characterized by a number of different types of societal structures. Historically, the four structural patterns discussed in this module and the way they related or continue to relate to the environment are of particular interest to Kansans.

References

1. Katz, Daniel and Robert Kahn. 1966. Chapter 2. The Social Psychology of Organizations. New York: John Wiley and Sons, Inc.
2. Webb, Walter Prescott. 1931. The Great Plains. New York: Grosset and Dunlap.

Module 53: Supplement #1

Table for Activity 1

	Native	Frontier	Rural - Town Farm Family	Mechanized Agri-business
Food Wild berries Cultivated fruits and vegetables Home processed Prepared Etc.				
Tools Local self-hand-made Locally crafted Simple machines Complex machines Etc.				
Shelter Sod Stone Lumber Leather Etc.				
Clothing Home-made Ready-made Types of fabric Etc.				
Power Human labor Hand Hand with animal power Mechanical				
Purpose of working land Survival Subsistence Economic profit				

Maps & Mapping

Welcome to the audio-tutorial unit on maps and map reading.

This unit has been designed to introduce you to basic mapping concepts and to help you develop skills in map utilization. A more detailed list of objectives is outlined on guide sheet number one...If you haven't read guide sheet #1, please stop the recorder and read the objectives for the unit now! (Pause 5 sec. Musical Interlude)

G.S. #1
Objectives
of maps unit

Before proceeding through a unit on maps and map reading, we might want to spend time discussing why this unit is so important in land use decision making.

There are many stories one can tell, about planning errors that have occurred simply because people were not skilled map readers.

One of the classic stories comes from a community in the Northeast, that agreed to the building of an airport on the outskirts of the city. Selecting the proper site was extremely important, so the community hired a consulting firm to study the area and make recommendations for the airport site.

The consulting firm was given twelve months to complete the study and make a presentation at a public meeting. They had no idea how significant the public meeting was to be!

Twelve months after engaging the consultants, the meeting was called and the consultants and interested citizens arrived. There was a great deal of excitement and speculation about the location of the new airport. The consultants got out their maps, transparencies and overlays and the meeting started.

A topographic map was shown on the overhead projector. In case you're not familar with topographic maps, they are maps that show details of the principal physical and cultural features of an area.

If we use terms that are new to you, and you don't understand stop the recorder and look for the term in the glossary for this unit.

Well, lets get on with the story. Now when the topographic map was displayed the consultant pointed out the major land forms, highways and population centers. Several open spaces surrounded the community and these were pointed out. Each one was discussed in terms of accessability, proximity to housing development and safety factors. Then came the long awaited moment, an overlay was put on the map and there was the airport layout complete with runways, buildings and other constructions details. Without waiting for reaction, the consultant pointed out the advantages of the site. There was an interstate highway close by, there were no housing centers in the landing or take off pattern for the proposed airport. The site would have the smallest possible impact on the citizens and the environment. It would not disrupt citizens of the community by producing inordinate noise levels in populated area, and it would prove to be an asset to the city. When the consultant finished his speech, he asked if there were any questions. A person in the back of the room raised their hand, and asked if the consultant really thought that this would be the best location. Once again, the consultant pointed out that for all of the reasons mentioned, this obviously would be the best place for the airport. The person that had brought up the question suggested that he felt the map was inaccurate, because if his memory served him properly, the runway went right through a subdivision that had been built recently.

It may sound unbelieveable, but when the person raising the question finished his statement there was no doubt about it! The runway went right through a housing development.

This stupendous error occurred because the consultant used maps that were out of date. Based upon the old map a good site was located, but the area was not field checked. As a result, the consultant picked a site that was very well suited for the airport based upon old information. In this real case the town and the consultant got a costly lesson.

The reason for telling this story is very simple. Some basic map reading skills may have saved the town and the consulting firm a great deal of money. Some preliminary work could have been done by an existing committee of the community and consultants might have been employed to obtain data that was not available to the city. There are many reputable firms and individiduals who can provide communities with environmental decision making information. But much information is already available on existing maps which can provide a base for decision making.

There are dozens of other stories that can be told about individuals, corporations and communities who have made costly land use errors because they were not able to interpret information on maps, or they simply did not take time to check. I'm sure you have read about developers who have purchased property in flood plains or in wetland areas, only to find that they could not build as they had planned...or the individual who got a bargain on the house of their dreams only to find that the noise of traffic or an interstate close to the property made sleeping difficult.

These and other problems can be avoided by obtaining and studying appropriate maps of your community.

This unit is designed to alert you to the importance of maps to the land use decision making process, and to acquaint you with the basic principles of map reading. In a "real life" situation, several types of maps would be utilized in decision making, including topographic maps, city plans and other planimertric and special subject maps. In this unit we will focus our attention on large scale topographic maps, such as the standard 1:24,000 quadrangle sheets published by the United States Geological Survey (USGS). One sheet in this series-the Wallingford Quadrangle-has been included in the unit and will be used in several exercises.

The competence you acquire working with the Wallingford Quadrangle will be valuable when you progress to the other units. In later units and in the process of land use decision making you will become involved in reading soils maps, land use maps, city plans and zoning maps as well as other special purpose maps. The principles governing topographic map reading, and the techniques employed, are similar and in many instances identical-to those required for reading other types of maps. Should you experience difficulty in reading the maps used in other units, it is suggested that you return to this unit and review the material presented here.

The remainder of this unit focuses on the development of an understanding of the various pictograph symbols used on topographic maps, an ability to translate there symbols into significant these distributional patterns and an awareness of the importance of distributional patterns to the decision making process. ~~If you complete all elements of~~ this unit in accordance with the instructions, you will acquire these skills. The specialized knowledge required for synthesizing map data and arriving at professionally sound land use decisions is quite complex and will require additional study beyond this introductory unit.

Before proceeding with the remaidar of the unit, arrange the guide sheets, topographic map and slides so that they will be handy for ready reference. In addition, you should spend the time necessary to familiarize yourself

with the terms contained in the Glossary on Guide Sheet 2. While you make these arrangements turn the recorder off...when you are ready to continue turn the recorder back on. (Pause 5 sec.)

Lets start with the basics...by definition, a map is a "two-dimensional representation of a portion of the earth's surface, this in accordance with a pre-determined scale and projection." This definition can be found in the glossary. Each point on a map must correspond exactly to its geographical location on the earth's surface. This definition is equally valid for topographic maps, city plans, and special subject maps. Variations in detail and data content do not change the basic definition.

In addition to the formal definition of "map", there are numerous statements about a map that contribute to a general understanding of its characteristics and use. A summary of such statements can be found at the bottom of Guide Sheet #2. (Pause)

1. A map is a shorthand method for representing part of the reality of the earth's surface;
2. A map is a selective, rigidly structured, and somewhat generalized, representation of a real situtation that emphasizes those elements relevant to the purpose for which the map was designed, and,
3. A map is an invaluable tool for the presentation of collected data, and for use as a base on which to display,evidence of an existing condition, project future development plans and record change.

The ability to read and interpret maps is a required competence for a professional planner, and a welcome attribute of a concerned citizen. To the planner, a properly designed map may summarize, in readily usable form, the results of many man-months of technical study. Further, when used in conjuction with the written report that customarily accompanies a technical study, maps provide the planner with essential data for land use decision making.

Concerned citizens who wish to interact with individuals responsible for land use planning will find it easier to do so if they are able to read and interpret maps. Land use decisions are generally made in conconance with a master plan that is summarized in map form, or planning guidelines illustrated by a series of maps. In addition, public hearings of local Planning and Zoning Commissions and Conservation Commissions frequently involve interpretations of technical data presented in map form

Maps used by planners fall naturally into two broad categores - those that are planimetric and those that are topographic. Planimetric maps are maps that indicate only horizontal positions, or north-south and east-west location of map features with respect to established baselines. Position is expressed in terms of one or another of several acceptable grid systems, latitude and longitude being most commonly used. Topographic maps contain, in addition to horizontal position, some indication of elevation. This is expressed in terms of feet or meters above an established datum plans, usually mean sea level (MSL).

Both planimetric and topographic maps are in common use in land use planning. Planimetric maps are normally employed to show single factor data for which reference to elevation would serve no useful purpose. For example, maps designed to show population distribution, dwelling types, road networks and numerous other cultural features are generally planimetric; although a topographic base map may be used for convenience. Topographic maps are, or should be, used whenever expressions of relief or elevation enhances the understanding of the data being presented.

Some planners, particularly those receiving their early training in geography, many classify maps according to function rather than the presence or absence of any indication of relief or elevation. The categories employed in this instance are topographic and special subject. The distinction is made in the purpose for which the map is designed. For example, a map compiled to show the road network of Connecticut would be classified as a special subject map even though the base used might contain "some indication of relief."

Finally, maps may be classified according to scale. If you refer to the glossary, you will find scale defined as the "ratio between distance on a map and distance on the earth's surface." Maps published at the scale of 1:600 ,000 and smaller are considered to be small scale maps. Those published at scales of 1:75,000 and 1:600,000 are classified as medium scale maps, and those that are scaled at a scale larger than 1:75,000 are large scale maps. Remember, the larger the second number in the ratio, the smaller the ratio, and thus the smaller the scale.

Persons accustomed to working primarily with topographic maps may restrict the classification "large scale" to maps published at scales between 1:20,000 and 1:75,000. This is in recognition of the fact that maps at a scale larger than 1:20,000 are normally special subject maps, and may or may not be compiled on a topographic base. Included are such items as city plans, maps of the various utility systems and cadastral maps. Cadastral maps are maps which show boundaries of particular tracts of land. A summary of the concept of scale can be found in section C at the bottom of Guide Sheet #2. Stop the recorder and review guide sheet 2C. When you are ready turn the recorder back on. G.S. #2

On the assumption that you have mastered the information presented in Guide Sheet 2, we will proceed to the first steps in map reading. All good maps contain, as a minimum, seven clues that can assist you in reading and interpreting the data presented on the map. These should be studied carefully before any concerted effort is made to read the body of the map.

The first clue may be found in the map title. Normally, a map title is either descriptive of the map content or of the geographic area covered. Occasionally, however, the title will contain information relative to either the date of the information or the publishing authority, or both. This is most common among special subject maps. TURN OFF THE RECORDER and study the map included in the unit to determine whether the title is descriptive of the content of the map or the geographic area covered. When you are ready, TURN RECORDER BACK ON. You're correct - the maps covers a geographic area.

Once you have learned everything possible from the title, examine the scale at which the map was published. Scale determines the amount of detail that can be shown clearly on any map-the larger the scale the greater the amount of detail and the nearer the map is to an expression of reality. If,for example, the Wallingford Quadrangle, which was published at the scale of 1:24,000, were reduced to one-half size, or to a scale of 1:48,000, much of the detail would either be lost or would become so small as to be insignificant. Such features as individual building, minor streets, small streams, and nurseries and orchards would "drop out." At the reduced scale, one-tenth of an inch on the map would represent 400 feet on the earth's surface. Even a toll road would be too small to show without gross exaggeration of reality. A further reduction in scale by one-half would result in the entire Wallingford Quadrangle being compressed to a sheet 4.25" x 5.50" and the loss of virtually all detail.

On the Wallingford Quadrangle sheet included in this unit, the scale is indicated in the middle of the border area at the bottom of the sheet. (Pause) Have you located the scale on your map? (Pause) Note that in addition to the ratio, commonly referred to as the Representative Fraction, or RF, bar or graphic scales are included. The particular advantage of the bar scale is that it facilitates the computation of distance on the map. Distance measurment is accomplished by using a ruler to measure map distance and calculating the representative distance on the earth's surface on the bar scale. Finally, note that the quadrangle sheet contains three different bar scales, thus permitting distance measurement in miles, feet or kilometers.

TURN OFF THE RECORDER and examine carefully the ways in which scale is indicated on the
use a ruler to measure some distances on the map,
Wallingford Quadrangle; then when you are ready to proceed TURN RECORDER BACK ON.

An additional technique is sometimes employed in indicating scale, particularly on maps designed for military specifications. This is a verbal statement of the distance on the map that is equivalent to one mile on the earth's surface. Thus, a quarter inch map is one on which the distance of one quarter inch on the map represents one mile on the earth's surface. Stated as a representative fraction, the quarter inch map is at a scale of 1:253,440. Similarly, a one inch map, restated, is at the scale of 1:63,360.

One of the early skills to be acquired in map reading is the ability to determine location of points of reference on a map. This is somewhat simplified when you recognize that north is customarily at the top of the map. The three systems most frequently used to determine location or points of reference are all incorporated in the Wallingford Quadrangle. Of the three methods, it is suggested that you first acquire competence in the use of latitude and longitude as a means of determining and expressing geographic location. Once this is done, the other two systems are relatively simple to learn.

The system of latitude and longitude is based upon the fact that the earth is round, or nearly so, and a circle has 360 degrees. Each degree, for accuracy of positioning, is divided into 60 minutes, and each minute into 60 seconds. Latitudinal values indicate position north or south of the equator, and longitudinal values establish position east or west of the prime meridian, a meridian of longitude passing through Greenwich Observatory, a short distance outside London, England. In stating location in terms of latitude and longitude, latitudinal position should be stated first. For example, Wallingford is located as 41° 27' N(orth) 72° 49' W(est). Since one second of latitude represents slightly less than 103 feet on the earth's surface, and a second of longitude about 75 feet it is usual to state locations of populated centers in degrees and minutes only. Longitude readings for a quadrangle are given at the top and bottom of longitude lines, while latitude readings are given at the end of latitude lines on the right and left margins of the map. Study your map carefully . . . do you see the latitude line 41°22'30'' at the bottom of the map? (Pause) What is the latitude at the top of the map? Correct! 41°30'. What is the longitude at the right margin of the map? Correct! 72° 45'. If you would like to study the latitude and longitude marks a little bit longer, stop the recorder, and turn it back on when you are ready to continue.

The second system employed a Connecticut state, or local, grid that subdivides the state into units 10,000 feet square. Precise positioning can be obtained by using an engineer's rule and calculating distance within the 10,000 square foot grid pattern. The third system is similar to the Connecticut grid, differing primarily in that the state is subdivided into units that are 1,000 meters This grid was developed by the U.S. Army Topographic Command for use in world wide military mapping. Again, precise positioning is possible by using an engineer's rule. If either of these systems is utilized, the value for the position corresponding to latitudinal location should be stated first.

TURN OFF THE RECORDER and study the systems of grid coordinates used in the design of the Wallingford Quadrangle, paying particular attention to the latitude and longitude system and the metric grid system. TURN ON THE RECORDER AND PROCEED with the unit when you are ready!

Investigation of direction

has major significance at the local and national level and for certain types of surveys. If you remember that maps are customarily oriented with north at the top, most of your requirements will be satisfied. The quadrangle actually contains three references to north direction. The middle arrow of the three arrows to the left of the bar scale indicates "true" north. The arrow on the left points toward "magnetic" north, or compass north; and the arrow on the right identifies the north orientation of the 1,000-meter grid. Have you found these three arrows to the left of the bar scales? Remember, the center shows true north, the left arrow points to magnetic north and the arrow on the right points to grid north. (Pause)

The next two items are frequently combined into a single statement on the map. The statement with respect to the date the map was published and the publishing authority is usually located along the lower margin outside the neat line - the line enclosing the body of the map. Information on the date that the map was published and the publishing authority is often very useful in assessing the reliability of the information contained on the body of the map;

The Wallingford Quadrangle contains, an overprinted statement in purple informing the user that some portions of the data were revised under an interim program, without resorting to a complete revision of the sheet. When was the Wallingford map completed? (Pause) Correct - 1967. In what year was the map photo-revised? Correct again . . . 1972. If you had any trouble answering these questions look closely at the lower right hand margin of the map . . . there you will see the answer to our questions!

The last item, and possibly the most significant, is the legend. Here is found, a complete listing of all symbols contained in the body of the map. The legend is often referred to as the map key, an association that is most appropriate; for the legend truly contains the key to map reading.

Map reading, then, is the art, or science, of associating the symbols contained on a map with the reality present on the earth's surface.

In instances where a map is but one sheet of a series, as is true of the Wallingford Quadrangle, it is customary to omit the legend. The map user who has yet to learn the

symbols has available a separate list that contains all symbols employed in the compilation of the series. The list included on Guide Sheet #3 contains Topographic Map Symbols, theoretically this Guide Sheet lists all symbols used in compiling the United States Geological Survey topographic sheets. Similar lists are available for geologic and soils maps, and for the maps of such specialized agencies as the United States Army Topographic Command. Study the Topographic map symbols sheet on Guide Sheet # 3. G.S. #3
Try and locate some of these symbols on the Wallingford Quadrangle map. Stop the recorder while you carry out this activity, when you are ready to proceed, turn the recorder back on.

In addition to the seven elements of maps discussed so far, two other items deserve comment before you undertake an exercise in map reading. One is the importance of color to map reading, and the other is the relevance of contour lines to map interpretation (note the distinction between map reading and map interpretation). The colors you see have not been selected haphazardly; rather, through use, there has evolved an association of color with a specific class of data. A list of colors and the class of data they represent can be found on Guide Sheet # 4.

Stop the tape recorder while you study Guide Sheet # 4. When you are ready, turn the recorder back on. G.S. # 4

Now that you have reviewed the colors you may in fact find when you are reading maps that certain tones and shadings appear that are different than those we have just discussed. In reality these are just the result of screening out of a portion of one of the above colors during printing. There is a

There is a self test at the bottom of Guide Sheet #4. Stop the recorder while you take the self test . . . then continue. (Pause) Let's check your answers. The school built between 1967 & 1972 would be purple. The reservoir and the Quinnipiac river would be blue. Downtown Wallingford is red, while the streets of Wallingford and the railroad tracks are black. The farms, orchards and the State Park will all be green. The old school is black and the Wilbur Cross Parkway is red. Before going any further, you might want to stop the recorder and take some time to study the map, paying particular attention to the use of color and identifying as many symbols as possible. (Pause)

Finally, a word about contour lines, the solid brown lines appearing on topographic maps are called contour lines. By definition, a contour line is "a line on a map that connects points of equal elevation above some prescribed datum plane, usually mean sea level." You will note that mean sea level is the datum plane for the Wallingford Quadrangle and that contours have been plotted at intervals of ten feet in elevation. The way that contour lines behave on a map tells much of the story of the topography of the area: the closer together the contour lines . . . the steeper the slope. In areas that are relatively flat, contour lines will be widely separated. Note, further, that every fifth contour line is heavier and contains a number. This number indicates the elevation above the datum plane. On the Wallingford map, the number represents height above sea level.

TURN OFF THE RECORDER and study the contours on the Wallingford Quadrangle map. When you are ready to continue, turn the recorder back on.

The remainder of the unit consists of a series of forteen slides that are keyed to the Wallingford Quadrangle. The purpose is to show how reality, as it exists on the earth's surface, has been captured by symbolization on a map.

Turn to Guide Sheet # 5. On Guide Sheet # 5, we have described the sites which you will observe in each slides. Place the slides in your viewer one at a time and read the description that matches the number of the slide, then look at the map. The fourteen sites are marked by bright triangles. Locate the site, and see how the photograph compares to the map symbol. Stop the recorder while you go through this exercise. Now that you have mastered some map reading skills you simply need to spend more time practicing. At the conclusion of this unit, spend time with your map, locating sites, measuring distances and determining which areas of the community are hilly or flat. There is a page of exercises at the conclusion of this unit to assist you in this exercise. Enjoy your study. G.S. #5

INSERT SLIDE # 1

> "FROM MOUNT HOLYOKE, ON THE SOUTHERN SIDE OF THIS TOWNSHIP, AT THE DISTANCE OF THREE MILES FROM THE CHURCH, IS SEEN THE RICHEST PROSPECT IN NEW-ENGLAND, AND NOT IMPROBABLY IN THE UNITED STATES. THE MOUNTAIN IS ABOUT ONE THOUSAND ONE HUNDRED FEET ABOVE THE SURFACE OF THE RIVER; BUT IN THE PLACE OF ASCENT IS OF SO GRADUAL AN ACCLIVITY, THAT TWO-THIRDS OF THE ELEVATION MAY BE EASILY GAINED ON HORSEBACK. ON THE HIGHEST PART OF THE SUMMIT, THE INHABITANTS HAVE CLEARED AWAY THE TREES AND SHRUBS, SO AS TO OPEN THE PROSPECT IN THE MOST ADVANTAGEOUS MANNER. FROM THIS SPOT THE EYE IS PRESENTED WITH A VAST EXPANSION TO THE SOUTH, COMPREHENDING THE SOUTHERN PART OF THE COUNTY OF HAMPSHIRE, AND A PORTION OF THE STATE OF CONNECTICUT. THE MIDDLETOWN MOUNTAINS, THE BLUE MOUNTAINS AT SOUTHINGTON, BOTH AT THE DISTANCE OF SIXTY MILES, AND THE WHOLE EXTENT OF THE CONNECTICUT VALLEY TO MIDDLETOWN, TOGETHER WITH THE LONG RANGES BY WHICH IT IS BORDERED, APPEAR IN FULL VIEW. THE VARIETY OF FARMS, FIELDS, AND FORESTS, OF CHURCHES AND VILLAGES, OF HILLS AND VALLIES, OF MOUNTAINS AND PLAINS, COMPRISED IN THIS SCENE, CAN NEITHER BE DESCRIBED NOR IMAGINED."

WITH THIS EXCERPT FROM TIMOTH DWIGHT'S, TRAVELS IN NEW ENGLAND AND NEW YORK, PUBLISHED IN 1821, WE WELCOME YOU TO THE AUDIO-TUTORIAL UNIT ON UPLANDS. IN THIS UNIT, WE WILL BE LOOKING AT SOME OF THE ECOLOGICAL FEATURES OF UPLANDS; WHAT THEY CONSTITUTE, WHERE THEY ARE FOUND, WHAT THEY CONSIST OF, AND WHY THEY ARE VERY IMPORTANT ECOLOGICAL ENTITIES WHICH SHOULD BE BOTH THOROUGHLY STUDIED AND CAREFULLY MANAGED. Slide #1

THE SCENE YOU HAVE BEEN LOOKING AT IN SLIDE #1 SHOWS TWO TYPES OF UPLAND AREAS, AN UPLAND FOREST AND AN UPLAND MEADOW . . . SLIDE # 2 SHOWS AND ADDITIONAL TYPE OF MAN MANAGED UPLAND AREA . . . A FARM. SLIDES ONE AND TWO HAVE SHOWN UPLAND SCENES THAT ARE TYPICAL OF MUCH OF THE NORTHEAST. slide #2

DO YOU SEE ANY COMMON CHARACTERISTICS OF THE TWO SCENES WHICH MIGHT PROVIDE A DESCRIPTION OF UPLANDS? (PAUSE) LET'S COMPARE YOUR OBSERVATIONS TO THOSE OF SCIENTISTS INVOLVED IN STUDYING UPLAND AREAS. TWO TYPES OF SCIENTISTS WHO ARE INTERESTED IN DESCRIBING AND INVESTIGATING UPLANDS ARE GEOLOGISTS AND BIOLOGISTS. GEOLOGISTS DESCRIBE UPLANDS IN TERMS OF THEIR TOPOGRAPHY AND SOIL TYPES. TO THE GEOLOGIST, AN UPLAND MAY BE ANY AND ALL TYPES OF TOPOGRAPHY OTHER THAN WATER FILLED DEPRESSIONS. GEOLOGICALLY UPLANDS ARE CATEGORIZED AS HILLS, SLOPES, RIDGES, DRUMLIN AND PLATEAUS, ALL OF WHICH HAVE ELEVATED, WELL DRAINED SOILS. TO A GEOLOGIST SUCH AREAS AS LAKES, MARSHES, PONDS, RIVERS AND STREAMS WOULD NOT BE UPLAND ECOSYSTEMS, ALTHOUGH THEY MAY OCCUR IN DEPRESSIONS IN THE MIDST OF UPLAND AREAS.

BIOLOGISTS DESCRIBE UPLANDS IN TERMS OF THE PLANTS AND ANIMALS WHICH ARE TYPICALLY FOUND IN SUCH AREAS. TO THE BIOLOGIST UPLANDS INCLUDE THE OAK-MAPLE OR HICKORY FORESTS WHICH COVER RIDGES AND HILLS, AND THE SUNFLOWER CARPETED FIELDS AND MEADOWS. OTHER UPLAND COMMUNITIES WOULD INCLUDE THE CEDAR AND ALDER BRUSH LAND, FARMS AND PASTURES, ORCHARDS AND NURSERIES.

A GOOD WORKABLE DEFINITION OF UPLANDS WOULD UNDOUBTEDLY HAVE TO INCORPORATE GEOLOGICAL AND BIOLOGICAL PARAMETERS.

AS WE BEGIN OUR STUDY OF UPLANDS, IT MAY BE HELPFUL TO SEE HOW UPLANDS RELATE TO OTHER MAJOR LAND AREAS. FOR MOST PURPOSES, LAND CAN CONVENIENTLY BE DESCRIBED IN TERMS OF THREE BROAD CATEGORIES: UPLANDS, (PAUSE) INLAND WETLANDS (PAUSE) AND COASTAL WETLANDS (PAUSE). NO SHARP LINES OF DEMARCATION SEPARATE THE THREE LAND TYPES, ALTHOUGH EACH MAY READILY BE DISTINGUISHED FROM EACH OF THE OTHERS. THE PATTERN OF THE THREE LAND TYPES FORMS A CONTINUUM FROM THE UPLANDS TO THE LOWLANDS TO THE COASTAL WETLANDS.

LOCATED ON GUIDE SHEET # 2 IS AN ILLUSTRATION OF THIS CONTINUUM. YOU CAN SEE THAT FORESTS COVER THE HIGH RIDGES AND STEEPER HILLS IN THE BACKGROUND. ON THE LESS STEEP SLOPES ARE FOUND FARMS, MEADOWS, PASTURES AND WOODLOTS. ALL OF THESE MAY BE CONSIDERED TO BE TRUE UPLAND AREAS. FURTHER DOWN THE SLOPES INTO THE G.S. #2

VALLEYS THE SOILS BECOME PROGRESSIVELY WETTER AND SUPPORT MORE WATER TOLERANT VEGETATION, HERE MAY BE FOUND PONDS AND MARSHES, WHICH ARE INLAND WETLANDS, EVEN THOUGH THEY MAY BE FOUND IN UPLAND AREAS. THESE ARE DRAINED BY STREAMS. THE STREAMS OF THE UPLANDS BECOME RIVERS OF T[illegible] LOWLANDS. THE LOWLAND RIVERS SLOW DOWN AS THEY SLUGGISHLY ENTER THE SEA, AND FREQUENTLY FORM VAST SALT MARSHES, SUCH AS ARE SHOWN IN THE FOREGROUND. THESE ARE THE COASTAL WETLANDS, AND THE CONTINUUM FROM THE UPLANDS TO THE COASTAL AREA IS COMPLETED. OTHER UNITS IN THE KIT DEAL WITH INLAND AND COASTAL WETLANDS.

A SUMMARY OF UPLAND CHARACTERISTICS IS PROVIDED FOR YOU AT THE BOTTOM OF GUIDE SHEET # 2.

LOOK AT GUIDE SHEET # 3A. GUIDE SHEET 3A DISPLAYS A MAP OF THE GENERAL TOPOGRAPHICAL G.S. #3 FEATURES OF THE STATE OF CONNECTICUT. NOTE THAT CONNECTICUT IS SUBDIVIDED INTO THREE BROAD TOPOGRAPHIC FORMS: COASTAL LOWLANDS, CENTRAL LOWLANDS, AND THE EASTERN AND WESTERN UPLANDS THE UPLANDS CONSIST OF LONG, PARALLEL RIDGES AND HILLS SEPARATED BY VALLEYS. FREQUENTLY THESE VALLEYS HAVE STREAMS OR RIVERS, SUCH AS THE HOUSATONIC RIVER IN THE WESTERN UPLANDS AND THE SHETUCKET RIVER IN THE EASTERN UPLANDS. THE RIDGES AND HILLS OF THE EASTERN AND WESTERN PORTIONS OF THE STATE FALL WITHIN OUR DEFINITION OF UPLANDS

IN CONTRAST TO THE UPLANDS A LOWLAND PLAIN OR VALLEY RUNS DOWN THE CENTER OF CONNECTICUT, SEPARATING THE HILLY EASTERN AND WESTERN PORTIONS OF THE STATE.

SLIDE # 3 WAS TAKEN IN CONNECTICUT'S WESTERN UPLANDS NEAR LAKEVILLE. THIS AREA NOT FAR slide #3 FROM THE UPPER HOUSATONIC RIVER SHOWN IN GUIDE SHEET # 3. SLIDE # 3 SHOWS THE SCENIC COUNTRYSIDE TO BE FOUND ALMOST ANYWHERE IN THE CONNECTICUT UPLANDS. IN THE SLIDES YOU WILL OBSERVE TYPICAL UPLAND AREAS SUCH AS FOREST, MEADOW, AND FARMS. SUCH SCENES CONSTANTLY REPEATED THROUGHOUT THE INTERIOR OF CONNECTICUT REVEAL THE COUNTRYSIDE TO BE A CONTINUING MOSAIC OF FARMS, MEADOWS AND FORESTS.

SOME UPLAND AREAS ARE MORE MODIFIED OR PERHAPS LESS NATURAL THAN OTHERS. FOR EXAMPLE, THE RIDGETOP FORESTS ARE AT THE PRESENT TIME, NATURAL AREAS LITTLE MODIFIED BY HUMAN ACTIVITY. THEY DO NOT, HOWEVER, REPRESENT VIRGIN TIMER STANDS. THE EARLY COLONISTS CUT OVER ALMOST ALL OF CONNECTICUT'S FORESTS FOR FIREWOOD AND CONSTRUCTION PURPOSES. WHAT FORESTS WE OBSERVE TODAY ARE SECONDARY REGROWTH FORESTS. FARMS AND PASTURES ARE OTHER FORMS OF MAN CHANGED UPLAND AREAS. THAT IS, THEY ARE AREAS WHICH SUPPORT DISTINCTIVE TYPES OF PLANTS AND ANIMALS DIRECTLY THROUGH MAN'S slide #4 ACTIVITIES. NOW LOOK AT SLIDE #4. A SURVEY OF UPLAND AREAS REVEALS OTHER INTENSELY MODIFIES AREAS SUCH AS POWER LINES, RAILROAD RIGHTS OF WAY, AIRPORTS, GOLF COURSES, SKI AREAS AND EVEN SNOWMOBILE TRAILS. THE POWER LINE YOU SEE IN SLIDE #4 SUPPORTS A UNIQUE SET OF BIOLOGICAL COMMUNITIES.

WE OUGHT FIRST TO POINT OUT THAT THERE ARE MANY DIFFERENT VIEW POINTS CONCERNING THE VARIOUS USES OF UPLANDS AND THE RELATIVE VALUES OF EACH USE. DEPENDING ON OUR PERSONAL VALUES, EACH OF US TEND TO ASSIGN PRIORITIES TO THE VARIETY OF USES THAT MAY BE MADE OF UPLANDS. THEREFORE, AS WE PROCEED THROUGH THIS UNIT, YOU MAY WANT TO KEEP A LIST OF THE ECOLOGICAL ROLE OF UPLANDS AND UPLAND USES. WE WILL ASK YOU TO RANK ORDER THESE USES INTO VITALLY IMPORTANT, MODERATELY IMPORTANT AND LESS IMPORTANT CATEGORIES. THE ACTIVITY ON GUIDE SHEET #3B WILL HELP YOU IN THIS PROCESS. FEEL FREE TO ADD NEW UPLAND TYPES OR USES TO EXPAND THE LIST. STOP THE RECORDER WHILE YOU COMPLETE THE ACTIVITY ON GUIDE SHEET #3B. (PAUSE) WE WILL G.S. #3B

FOCUS OUR ATTENTION ON UPLANDS AND THEIR USES AND VALUES BY CONCENTRATING ON THE TWO MOST COMMON TYPES OF UPLANDS IN CONNECTICUT: (1) A COMPLETELY NATURAL UPLAND AREA, THE FOREST, AND, (2) A MAN MODIFIED UPLAND SYSTEM, THE FARM.

HISTORICALLY, MAN HAS ALWAYS BEEN AWARE OF THE BEAUTY AND SOLITUDE OF FORESTS. TODAY, WE SEEM TO FIND FORESTS APPEALING BECAUSE THEY PROVIDE US WITH SCENIC DIVERSITY AND QUIET RETREATS FROM OUR DAILY ACTIVITY. IN THE FORESTS, WE OFTEN FIND RELAXATION IN THE FORM OF SUCH RECREATIONAL ACTIVITIES AS BIRD WATCHING, CAMPING, FISHING, HIKING AND HUNTING.

THE ECOLOGICAL DIVERSITY OF FORESTED AREAS PROVIDES PRODUCTIVE HABITAT FOR A BROAD SPECTRUM OF WILDLIFE. IT IS THIS SAME DIVERSITY WHICH MAKES THE FORESTS SUCH INTERESTING LAND AREAS FOR MAN TO EXPLORE AND ENJOY. .

THUS THE VALUE OF FORESTS WHICH WE HAVE CONSIDERED HELP TO IMMEASURABLY IMPROVE THE "QUALITY OF LIFE." WE SEE THESE VALUES REFLECTED IN THE ATTITUDE OF MODERN MAN IN THE CURRENT "BACK TO THE LAND MOVEMENT" IN WHICH CITY DWELLERS ARE ABANDONING THE CITY ENVIRONMENT FOR THE RURAL ENVIRONMENTS TYPIFIED BY FORESTED UPLANDS.

THE HISTORY OF CONNECTICUT'S FORESTS, INDICATE THAT THEY HAVE NOT ALWAYS FIGURED SO PROMINATELY AS OBJECTS FOR PRESERVATION AND RECREATION.

WHEN THE FIRST COLONISTS ARRIVED, ALMOST ALL OF CONNECTICUT WAS COVERED BY HARDWOOD AND EVERGREEN FORESTS. EXCEPT FOR PORTIONS OF THE COASTAL LOWLANDS AND AREAS ALONG RIVER COURSES, THE STATE WAS ONE HUGE FORESTS, BROKEN ONLY BY SMALL CLEARINGS MADE BY THE INDIANS FOR VILLAGES AND FILLED FIELDS. THE FOREST WAS SO DENSE THAT TRAVEL WAS POSSIBLE ONLY ALONG WATERWAYS AND BY INDIAN TRAILS THROUGH THE WOODS.

THE IMMEDIATE CONCERN OF THE EARLY COLONISTS WAS SURVIVAL. SO THEY USED THE FORESTS INTENSIVELY AND GAVE NO THOUGHT TO FOREST PRESERVATION. TREES WERE FELLED TO PROVIDE LUMBER FOR HOME AND FIREWOOD FOR FUEL. MUCH TIMBER WAS EXPORTED OVERSEAS TO EUROPEAN COUNTRIES. SOME WAS UTILIZED FOR SHIP BUILDING. FOR EXAMPLE, THE ESSEX, A FAMOUS FRIGATE OF THE WAR OF 1812 WAS CONSTRUCTED FROM CONNECTICUT OAK IN ESSEX, CONNECTICUT.

AS EACH CONNECTICUT INDUSTRY EXPANDED, MUCH OF THE FOREST'S WERE CUT AND THE WOOD UTILIZED TO CREATE ENERGY FOR THE SMELTING OF IRON AND BRASS. BY THE EARLY 1800'S DOMESTIC, COMMERCIAL AND INDUSTRIAL USE HAD CONSUMED ALMOST ALL OF CONNECTICUT FORESTS AND TREES WERE SPARSE. AN EXAMPLE OF THIS IS READILY EVIDENT BY COMPARING A SLIDE OF THE CITY OF NEW HAVEN AS IT APPEARED IN THE 1800'S WITH ITS APPEARENCE TODAY. TAKE A LOOK AT SLIDE # 5. NOTE THE SPARSITY OF TREES IN AND AROUND THE CITY. NOW THAT REFORESTATION HAS OCCURRED YOU CAN JUDGE FOR YOURSELF WHICH SCENE IS MORE APPEALING; NEW HAVEN THEN OR NEW HAVEN TODAY, shown in slide # 6. Stop the recorder while you compare slides # 5 & 6 of New Haven in early 1800's with slide # 6 showing New Haven Today.

slide #5

slide #6

WHY DID REFORESTATION OCCUR? THE ANSWERS MAY BE FOUND IN THE ECONOMICS OF CHANGING LAND USE PATTERNS AND A GROWING AWARENESS OF THE IMPORTANCE OF FORESTS AND FORESTRY. RECURRENT RECESSIONS AND DEPRESSIONS DURING THE 1800'S CAUSED THE ABANDONMENT OF MARGINAL FARMS. OTHERS WERE ABANDONED WHEN THEIR OWNERS TOOK FACTORY JOBS SPAWNED BY THE GROWING IN-

DUSTRIAL REVOLUTION OR JOINED THE GREAT WESTWARD MIGRATIONS. THE LAND LEFT BEHIND REVERTED TO WOODS, THROUGH A NATURAL, ECOLOGICAL PROCESS CALLED SUCCESSION, WHICH WE WILL DISCUSS LATER IN THIS UNIT.

IN THE EARLY 1900'S LEGISLATION WAS PASSED WHICH MADE FORESTS ATTRACTIVE ECONOMIC INVESTMENTS. FOR EXAMPLE, WITH THE SUPPORT AND ENCOURAGEMENT OF PROFESSIONAL FORESTERS FROM YALE AND THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION, THE STATE PASSED THE FOREST TAX LAW IN 1913. THIS LAW MADE IT POSSIBLE FOR LANDOWNERS TO DEFER TAX ON TIMBER UNTIL THE TREES WERE ACTUALLY CUT, THEREBY ENCOURAGING THE PRESERVATION OF FORESTS.

EFFECTIVE FOREST FIRE CONTROL MEASURES, WHICH WERE FIRST INTRODUCED IN 1921, ALSO HELPED BY GREATLY REDUCING THE AMOUNT OF TIMBER OTHERWISE LOST IN FREQUENT FOREST FIRES.

RECENTLY LAWS HAVE BEEN ENACTED WHICH ALLOW THE PURCHASE AND PRESERVATION OF FORESTED LAND PUT UP FOR SALE.

AS A RESULT OF THESE MEASURES, CONNECTICUT TODAY IS HEAVILY FORESTED, DESPITE THE FACT THAT IT IS THE FOURTH MOST DENSELY POPULATED STATE IN THE COUNTRY. APPROXIMATELY 50% OF CONNECTICUT'S 3 MILLION ACRES ARE COVERED WITH FORESTS. THE PRESENT FORESTS ARE IN THE FORM OF FARM WOODLOTS, FORESTS COVERING HILLS AND STEEP SIDED RIDGES, AND STATE PARKS AND FORESTS.

MANY CONNECTICUT FORESTS ACTUALLY OWE THEIR EXISTENCE TO THEIR LOCATION ON STEEP SLOPES, ROCKY HILLSIDES AND OTHER RELATIVELY INACCESSIBLE SITES. THESE FORESTS HAVE BEEN LEFT IN THEIR NATURAL STATE SIMPLY BECAUSE THEY COULD NOT BE READILY OR ECONOMICALLY UTILIZED. WE ARE FORTUNATE IN THIS RESPECT BECAUSE THESE FORESTS, IN THEIR PRESENT, INTACT STATE, ARE FAR MORE VALUABLE THEN THEY WOULD BE IF THEY HAD BEEN CUT DOWN AND CONVERTED TO LUMBER. THESE FORESTS, OVER THE YEARS, HAVE CONTRIBUTED AND WILL CONTINUE TO CONTRIBUTE, A GREAT DEAL TO EVERYONE. THEIR PRESENCE CUTS DOWN OR PREVENTS SOIL EROSION, THUS PRESERVING A VALUABLE RESOURCE. THEY PROVIDE NATURAL SETTINGS FOR RECREATIONAL ACTIVITIES SUCH AS HIKING AND CAMPING, AND THEY ARE VERY IMPORTANT ELEMENTS OF THE WATERSHED.

OVER 85% OF THE FORESTED LAND IN CONNECTICUT IS OWNED BY PRIVATE INDIVIDUALS. THEY DERIVE AN ECONOMIC INCENTIVE FOR KEEPING THE FORESTS. MODERN METHODS OF FOREST MANAGEMENT MAY MAKE IT POSSIBLE TO OBTAIN LUMBER FROM THEM WHILE STILL MAINTAINING THEM VIRTUALLY INTACT. AS REVEALED IN A 1974 STUDY BY NEW ENGLAND RESEARCH, INC., THESE OWNERS NOT ONLY ENJOY INCOME FROM THEIR WOODLOTS, BUT ALSO ENJOY RECREATIONAL ACTIVITIES SUCH AS HIKING, HUNTING AND CAMPING IN THEM.

AN IMPORTANT VALUE OF A FOREST STEMS FROM THE FACT THAT IT IS A STABLE AND SELF PRESERVING ENVIRONMENT. IF LEFT ALONE THE FOREST WILL REMAIN ESSENTIALLY THE SAME FOR HUNDREDS PERHAPS THOUSANDS OF YEARS. FORESTS ARE STABLE BECAUSE THEY HAVE A GREAT VARIETY OF PLANT AND ANIMAL LIFE. THIS ALSO IS ONE REASON WHY THEY ARE AESTHETICALLY PLEASING. MAKE A NOTE TO YOURSELF THAT YOU ARE GOING TO TAKE ANOTHER LOOK AT THAT NEIGHBORHOOD WOODLOT YOU HAVE PASSED BY SO MANY TIMES. YOU MAY BE SUPRISED TO DISCOVER JUST HOW COMPLEX A WOODLOT OR A FOREST ACTUALLY IS.

You may gain an appreciation of the structure and complexity of a forest by first looking at the slide # 7 of the interior of a forest. Do you notice any distinctive horizontal layers slide #7 in the forest? How many do you see? Look at guide sheet # 4. Did you find the four distinct regions or layers that are illustrated on guide sheet # 4? G.S. #5 A layer consists of trees which form the roof or canopy of the forest. Below the canopy is a second layer of smaller trees (Layer B) which forms an understory. Closer to the ground is layer C, which is composed of small trees and shrubs, such as our state flower, the Mountain Laurel. Layer D consists of the herbs and ferns of the forest floor. Each of these different layers of vegetation provides a wide variety of hiding and feeding places for animals. Warblers, orioles and squirrels may nest and feed high in the canopy or tree top layers of vegetation. Further below in the understory or tall shrub layer, we may find robins and tanagers. Chipmunks and a variety of mice may be found feeding and hiding in the vegetation comprising the forest floor.

Ecologists use the term diversity to indicate the variety of plant and animal life. Diversity refers to the number of different kinds of plants and animals to be found. For example, compare the hard wood forest community in slide # 7 with a planted and slide #8 managed cornfield in slide # 8. (Pause) Are you impressed with the great variety of vegetation to be found in the forest as compared to the cornfield. In analyzing the diverse vegetation we find some trees to be common, others to be abundant and a few to be rare. The diversity of the forest not only is aesthetically pleasing to us but also makes it a more stable community. The diversity of the forests promotes stability by spreading the risk of natural disaster among all of the species of trees. Thus if a disease appears and destroys one particular species, other species take over and maintain the forest.

An excellent case study in the Northeast involves the chestnut trees . . . Originally the American Chestnut was an important member of the Connecticut forests. In 1904, a chestnut fungus was accidentally introduced into the United States from China. The American chestnut proved to be susceptable to the new fungus and the the chestnut trees quickly died. By 1952 all large Chestnut trees in the U.S. had been killed. Yet, the appearance of the forest remained essentially the same. Other trees had simply taken over the place of the once predominant Chestnut.

Contrast the stability of a forest compared to that of land devoted to farming, one type of plant covers large expanses of land. A system in which a large land area is covered by a single type of vegetation is called a monoculture. As you have probably guessed, a monoculture is much less stable than a forest. A good example of the potential instability of a monoculture such as corn, occurred in 1970. In that year a new strain of disease called corn leaf blight suddenly appeared. It spread rapidly from one corn field to another in the Midwest because most of the vegetation in adjacent

FIELDS WAS OF THE SAME SUSCEPTIBLE VARIETY. THE NEW DISEASE WAS LIGHTLY LETHAL AND CAUSED A 12% LOSS OF THE CORN CROP FOR THAT YEAR. A MONOCULTURED SYSTEM IS FAR LESS ABLE TO SURVIVE NATURE OR MAN CAUSED DISASTERS THAN IS A DIVERSE ECOSYSTEM.

DIVERSITY THUS PROVIDES GREATER INSURANCE AGAINST RISK OF LOSS OF THE FOREST THROUGH THE RESULT OF A NATURAL CATASTROPHE. FINALLY THE DIVERSITY OF THE FOREST VEGETATION PROVIDES MANY SUITABLE NICHES OR SMALL HABITATS FOR A GREAT VARIETY OF ANIMALS, THEREBY ENSURING A DIVERSITY OF ANIMAL LIFE. AGAIN, HARMONY AND STABILITY ARE PROMOTED, AND WE ARE PROVIDED WITH AN AESTHETICALLY PLEASING ENVIRONMENT. THE DIVERSIFIED FOREST COMMUNITY MAKES FULLER USE OF THE SUN'S ENERGY BECAUSE ALL OF THE AVAILABLE HABITATS ARE FILLED, THEREBY INCREASING THE PRODUCTION OF SUCH FOREST PRODUCTS AS LUMBER.

FINALLY, WE SHOULD NOTE THAT MAN SEEMS TO REQUIRE DIVERSITY SUCH AS THAT PROVIDED IN FORESTS FOR HIS MENTAL ENJOYMENT. INDEED, MAN ALMOST ALWAYS, WHEN GIVEN THE CHOICE, OPTS FOR DIVERSITY, AND SOCIO-BEHAVIORIAL STUDIES SUGGESTING THAT NATURAL DIVERSITY SEEMS TO BE A NECESSARY REQUIREMENT FOR OUR OPTIMUM HEALTH AND WELL BEING.

BECAUSE A FOREST OR WOODLOT TENDS TO BE A STABLE ENVIRONMENT, IT REQUIRES LITTLE OR NO MONETARY INPUT FOR CONTINUED MAINTENANCE AND PRESERVATION.

IF DISTURBED, FORESTS HAVE THE ABILITY TO REPAIR AND REGENERATE THEMSELVES THROUGH A PROGRESSIVE SERIES OF STAGES. THIS REGENERATIVE PROCESS IS CALLED SUCCESSION.

ON GUIDE SHEET # 5 YOU WILL FIND A SIMPLIFIED OUTLINE OF THE MAJOR STEPS IN THE PROCESS OF SUCCESSION. REFER TO GUIDE SHEET # 5 WHILE THE TAPE RECORDER KEEPS PLAYING.

G.S. #5

IT IS IMPORTANT TO NOTE THAT ALL FORMS OF MODIFIED LAND, WHETHER IT BE CROPLAND, PASTURE, A BURNED OVER FOREST OR EVEN A SANITARY LANDFILL SITE WILL WHEN ABANDONED, GO THROUGH THE ORDERLY PROCESS OF SUCCESSION AND EVENTUALLY REACH A RELATIVELY STABLE CLIMAX STATE. IN THE UPLAND AREAS OF THE NORTHEAST, FORESTS REPRESENT THE CLIMAX STAGE OF THE PROCESS OF SUCCESSION. DURING THE DEPRESSION OF THE 1930'S MANY FARMS IN THE NORTHEASTERN STATES WERE ABANDONED. THE CROP AND PASTURE LAND FIRST BECAME WEED COVERED FIELDS. THE WEEDS IN TURN WERE REPLACED BY SCATTERED CEDARS, THEN BY BIRCH AND RED MAPLE, UNTIL THE FORESTS ONCE AGAIN STOOD WHERE THEY WERE BEFORE THE LAND WAS FIRST CLEARED FOR FARMING.

ANOTHER DEMONSTRATION OF THE PROCESS OF SUCCESSION CAN BE OBSERVED WHEN A FOREST IS BURNED OVER OR PERHAPS CUT AWAY, LEAVING BEHIND BARE GROUND. THE BARE EARTH FORMED AN INVITING HABITAT FOR SOME TYPES OF PLANTS SUCH AS CRABGRASS WHICH RAPIDLY INVADES THE OPEN AREA. WITHIN A YEAR THE BARE FIELD WILL BE TRANSFORMED INTO A SIMPLE COMMUNITY OF CRABGRASS. THE CRABGRASS COMMUNITY IN TURN FORMS AN INVITING HABITAT FOR SMALL ANIMALS, AND A VARIETY OF SPIDERS, ANTS AND GRASSHOPPERS TAKE UP RESIDENCE IN THE CRABGRASS FIELD. THESE PIONEERS, AS THE INITIAL PLANTS AND ANIMAL INVADERS ARE TERMED, SOON CHANGE THE NATURE OF THE COMMUNITY. THROUGH THEIR LIFE ACTIVITIES THEY ESTABLISH A BETTER SOIL BASE AND STABILIZE THE ENVIRONMENT OF THE CRABGRASS COMMUNITY. THIS STABILI-

ZATION SOON ALLOWS THE INVASION OF OTHER PLANTS WHICH TRANSFORMS THE CRABGRASS COMMUNITY INTO A FIELD OF WEEDS SUCH AS HOUSEWEED, MILKWEED, ASTERS AND GOLDENROD AS IS SHOWN IN SLIDE # 9. THE NEW PLANTS ALLOW MORE ANIMALS TO COLONIZE THE AREA, AND A VARIETY slide #9 OF BUTTERFLIES, AND OTHER INSECTS MAKE THEIR APPEARANCE. AGAIN THE PROCESS OF ENVIRONMENTAL ALTERATION BY THE PLANTS AND ANIMALS OCCURS, AND WITHIN ABOUT SIX YEARS THE WEED STREWN FIELD BECOMES A GRASSLAND. NOW THE PROCESS OF CHANGE ACCELERATES. THE GRASS ROOTS PENETRATE DEEPLY INTO THE EARTH, AIDING IN SOIL FORMATION. IN ADDITION, THE GRASSES PRODUCE AND ACCUMULATE A GOOD DEAL OF ORGANIC MATTER. THIS NEW TRANSFORMATION ALLOWS SHRUBS TO INVADE THE AREA AS SHOWN IN SLIDE # 10. WE FIND CEDAR, ALDER AND slide #10 BARBERRY CROWDING OUT THE GRASSES. IN SLIDE #10 THE CEDAR TREES RANGE IN AGE FROM ABOUT 3 TO 10 YEARS OF AGE. REMNENTS OF THE PREVIOUS GRASSLAND STAGE MAY BE SEEN IN THE AREAS BETWEEN THE CEDARS.

THE CEDAR AND SHRUB FIELD ENCOURAGES THE ENTRY OF MORE ANIMALS, PARTICULARLY BIRDS SUCH AS FIELD SPARROWS AND BLUEBIRDS. THE BIRDS FIND THE SHRUBS TO BE GOOD NESTING PLACES AND THE INTERVENING PATCHES OF FIELD ARE GOOD AREAS TO SEARCH FOR FOOD. WITHIN A FEW YEARS CONIFERS BECOME THE DOMINANT SHRUB FORM, AND AS THEY GROW TO MATURITY, THE SHRUB COMMUNITY IS TRANSFORMED INTO A PINE FOREST WHICH MAY PERSIST FOR THIRTY OR FOURTY YEARS. EVENTUALLY SEEDLINGS OF OAK, MAPLE AND HICKORY BECOME ESTABLISHED ON THE FOREST FLOOR. AS THEY MATURE, THEY DISPLACE THE PINE TREES AND EVENTUALLY A CLIMAX FOREST OR HARDWOOD TREES IS ESTABLISHED. NOW A GREAT MANY SPECIES OF ANIMALS WILL BE ABLE TO FIND SUITABLE HABITATS AND INVADE THE FOREST. FINALLY, THE BURNED OUT AREA HAS BECOME A COMPLEX AND DIVERSIFIED ECOLOGICAL COMMUNITY. BECAUSE THE FOREST IS THE FINAL AND PERMANENT COMMUNITY IT IS CALLED THE CLIMAX HARDWOOD COMMUNITY. ECOLOGICAL SUCCESSION, WHICH, FROM START TO FINISH TOOK PERHAPS 100 YEARS IS NOW FINISHED.

A STYLIZED DIAGRAM ILLUSTRATING THE TIME SCALE OF SUCCESSION IS PRESENT IN GUIDE SHEET # 5. THE STYLIZED DIAGRAM SHOWS A TYPICAL FOREST G.S. #5 SUCCESSION PATTERN EOUND IN THIS AREA. STOP THE RECORDER, WHILE YOU STUDY GUIDE SHEET # 5.

THE REGENERATIVE CAPACITY OF FOREST SHOULD NOT LULL US INTO A FALSE SENSE OF SECURITY. UNFORTUNATELY, THE 100 YEARS IT TAKES FOR NATURE TO REPRODUCE A FOREST IS IN FACT A LONG TIME, AND THE AREA MAY BE ESSENTIALLY AN UNUSUAL WASTELAND FOR THAT PERIOD. WE SHOULD CAREFULLY MAINTAIN OUR FORESTS, RATHER THAN DEPEND ON NATURE TO CORRECT OUR MISTAKES!

FORESTS PLAY AN IMPORTANT ROLE IN THE WATER SUPPLY SYSTEM OF MANY COMMUNITIES. AS A RESULT, WATER COMPANIES MAINTAIN FORESTS FOR ECONOMIC REASONS. THE BUSINESS OF WATER COMPANIES IS TO COLLECT, TREAT AND SELL WATER. IN MANY COMMUNITIES, WATER IS COLLECTED FROM WATERSHEDS. A WATERSHED IS THE LAND FROM WHICH WATER DRAINS INTO A RIVER, LAKE OR RESERVOIR. THE CLEANER THE WATER COLLECTED, THE LESS TREATMENT IS REQUIRED AND THE

CHEAPER THE FINAL COST. A WATERSHED COVERED BY FORESTS YIELDS MUCH MORE CLEAN WATER THAN DOES BARE LAND. THE IMPORTANCE OF FOREST COVER ON WATERSHEDS HAS BEEN WELL DOCUMENTED BY A SERIES OF INVESTIGATIONS CONDUCTED BY YALE AND CORNELL FORESTRY SCIENTISTS AT HUBBARD BROOK FOREST IN NEW HAMPSHIRE.

HUBBARD BROOK EXPERIMENTAL FOREST PROVIDED ECOLOGISTS, DR. HERBERT BORMANN, DR. GENE LIKENS AND THEIR COLLEAGUES, A VALUABLE OPPORTUNITY TO STUDY AND INTERPRET THE FUNCTION OF THE FOREST ECOSYSTEM. FOR SEVERAL YEARS, THEY STUDIED TWO ADJACENT WATERSHEDS AT HUBBARD BROOK FOREST. THEY COLLECTED DATA ON WATER FLOW, SOIL EROSION, MINERAL LOSS AND MANY OTHER VARIABLES. IN 1966, THE FIRST MAJOR EXPERIMENT WAS CONDUCTED - EVERY SINGLE PLANT AND TREE ON WATERSHED 2 A 39 ACRE PLOT WAS CUT DOWN! THE ADJACENT WATERSHED 1, WAS LEFT UNDISTURBED.

AS A RESULT OF THE DENUDING OF THE FOREST, RESEARCHERS FOUND THAT THE QUANTITY AND QUALITY OF THE WATER COLLECTED FROM THIS AREA OF THE WATERSHED HAD CHANGED DRAMATICALLY. GUIDESHEET # 6 PRESENTS SOME OF THEIR RESULTS. G.S. #6

ON GUIDE SHEET # 6 PART A THE RESULTS OF THE EXPERIMENT ARE PRESENTED GRAPHICALLY. THE SOLID LINE REPRESENTS CONDITIONS IN THE UNCUT FOREST, WATERSHED 1. THE DOTTED LINE REPRESENTS THE CLEAR CUT OR DENUDED WATERSHED 2. AS YOU CAN SEE, THE LEVEL OF WATER, SOIL AND MINERAL LOSS IS LOWER IN THE FORESTED AREA THAN THE CLEARCUT AREA. PART B OF GUIDE SHEET # 6 HAS A PARTIAL LISTING OF THE DISSOLVED SOLIDS LOSS FOR BOTH WATERSHEDS, DURING TWO, TWO YEAR STUDY PERIODS. TURN OFF THE RECORDER IF YOU WOULD LIKE TO HAVE MORE TIME TO STUDY GUIDE SHEET # 6.

GUIDE SHEET # 6 SUGGESTS TWO WAYS IN WHICH FORESTS HELP ALLEVIATE WATER POLLUTION - BY RETENTION OF SOIL AND MINERALS. LOSS OF SOIL IN CUT OVER AREAS MAKES WATER CLOUDY AND MURKY. IF FORESTS ARE LEFT UNDISTURBED VERY LITTLE SOIL ERODES INTO NEIGHBORING WATERWAYS. LOSS OF DISSOLVED SOLIDS FROM WATERSHEDS IS GREATLY HASTENED BY CLEARCUTTING AS POINTED OUT DRAMATICALLY IN GUIDE SHEET # 6B. IN FACT, SOME DISSOLVED MATERIALS SUCH AS NITRATES, ARE LOST AT THE RATE OF 30 AND 40 TIMES FASTER FROM AREAS WHERE THE FORESTS HAVE BEEN REMOVED. MINERALS SUCH AS NITROGEN AND PHOSPHOROUS, ARTIFICIALLY ENRICH WATERS AND MAY LEAD TO THE DESTRUCTION OF ORGANISMS IN DOWNSTREAM RIVERS AND LAKES.

THE LIVING ORGANISMS OF FORESTS CLEAN WATER THROUGH THEIR TRAPPING OR ABSORPTION OF POLLUTANTS. THIS PHENOMENON OCCURS BECAUSE FOREST VEGETATION ABSORBS AND PROCESSES WATER AT AN ASTOUNDING RATE. FOR EXAMPLE, A SINGLE TREE MAY PROCESS 80 GALLONS OF WATER IN ONE DAY. THE POLLUTANTS IN THE WATER ABSORBED BY THE TREE ARE REMOVED AND STORED IN WOODY PLANT TISSUE.

IT'S EASY TO SEE WHY WATER COMPANIES WANT FOREST ON THEIR WATERSHED. THE VEGETATION OF THE FOREST AIDS IN RETAINING AND CLEANSING WATER IN AN AREA. REMOVE THE VEGETATION AND THE WATER HOLDING CAPABILITY OF THE LAND DROPS DRASTICALLY. FOR EVERY CUBIC FOOT OF WATER THAT FALLS ON A FOREST ECOSYSTEM ABOUT 80% IS ABSORBED AND RETAINED, CHIEFLY BY THE FOREST VEGETATION AND ITS HUMUS SOIL BASE. THE REMAINING 20% PERCOLATES DOWNWARD THROUGH THE SOIL AND EVENTUALLY ENTERS THE WATER TABLE. FOR THIS REASON, INTACT, FORESTED WATERSHEDS ARE IMPORTANT FOR FLOOD CONTROL. THROUGH THEIR ABILITY TO SLOW AND STORE WATER, THEY HELP TO REDUCE DAMAGE FROM FLOODS. IN CONTRAST, UPLAND AREAS FROM WHICH THE VEGETATION COVER HAS BEEN REDUCED OR ELIMINATED DO NOT HOLD WATER EFFECTIVELY. WATER LOSS FROM SUCH AREAS IS VERY HIGH AND INCREASES THE LIKELIHOOD OF FLOODS. THE CATASTROPHIC FLOODS WHICH OCCURRED OVER PORTIONS OF THE EASTERN UNITED STATES IN JUNE OF 1973 WERE DUE IN PART TO THE REDUCED WATER HOLDING CAPABILITY OF UPLAND AREAS WHICH HAD BEEN CLEAR CUT FOR TIMBER, OR TO MAKE WAY FOR SHOPPING CENTERS, INDUSTRIAL PARKS OR SUBURBAN HOUSING.

FOREST OR WOODLOTS CAN ALSO HELP COMBAT NOISE POLLUTION. AS SHOWN IN GUIDE SHEET #7B, TREES ALONGSIDE ROADWAYS, RAILROAD RIGHTS OF WAY AND THE BORDERS OF AIRPORTS ACT AS ACOUSTIC BARRIERS, WHICH HELP ABSORB AND MUFFLE THE SOUNDS OF PASSING VEHICLES. THEY MAY ALSO DEFLECT THE SOUND UPWARDS. IN THE EXAMPLE ON GUIDE SHEET #7B THE ROAD WOODLOT REDUCES THE NOISE POLLUTION FROM A HIGH OF ABOUT 85 DECIBELS; THE EXPECTED NOISE LEVEL OF TRAFFIC AT ROADSIDE, DOWN TO ONLY 5-10 DECIBELS. THIS REPRESENTS A SIGNIFICANT LESSENING OF THE NOISE TRANSMITTED INTO AREAS ADJACENT TO ROADWAYS. WOODLOTS AROUND AIRPORTS AND ALONG MAJOR HIGHWAYS PROVIDE IMPORTANT NOISE SHIELDING MECHANISMS. G.S. #7B

TREES ALSO CLEANSE AIR AS THEY PROCESS IT AS PART OF THEIR METABOLIC PROCESSES as shown in guide sheet #7A. CONSIDER THIS, A FOREST OF TREES 15 FEET TALL WILL FILTER POLLUTED AIR CONTAINING 150 PARTS PER BILLION OF OZONE, A HEALTH HAZARD, SO THAT AIR REACHING THE GROUND ONLY CONTAINS A CONCENTRATION OF 30 PARTS PER BILLION. One 40 square meter block of vegetation will provide the oxygen required by one man or woman. MOREOVER, ONE ACRE OF VEGETATION WILL TRAP THE OZONE FROM EIGHT AUTOMOBILES OR THE CARBON DIOXIDE FROM FIFTY. HOWEVER, TREES ALONE DON'T PROVIDE THE ANSWER TO OUR NATIONAL AIR POLLUTION PROBLEM BECAUSE THEY TOO, MAY BE DAMAGED BY HIGH LEVELS OF POLLUTION. Plant damage caused by air pollution can be seen in slide # 11. G.S. #7A Slide #11

FINALLY, LET US CONSIDER THE ECONOMIC BENEFITS DERIVED FROM THE SELECTIVE HARVESTING OF CONNECTICUT'S FORESTS. WOODLANDS REPRESENT A RENEWABLE RESOURCE WHICH, WHEN PROPERLY MANAGED AND HARVESTED PROVIDE LUMBER FOR A VARIETY OF PURPOSES. SOFTWOODS, SUCH AS PINES AND HEMLOCKS, FOR EXAMPLE, ARE USED FOR HOUSING CONSTRUCTION. CEDARS ARE USED FOR POLES AND POSTS. OAKS AND MAPLES AND BIRCHES ARE USED FOR FURNITURE CONSTRUCTION. A VARIETY OF TREES MAY ALSO BE USED FOR FIREWOOD AND FOR PULP AND PAPER MANUFACTURE. THUS TIMBER HARVESTING STIMULATES A DIVERSITY OF INDUSTRIES AND PROVIDES EMPLOYMENT FOR THE CONNECTICUT LABOR FORCE. UNFORTUNATELY, ONLY ABOUT ONE-FIFTH OF THE ANNUAL TIMBER GROWTH IS ACTUALLY HARVESTED. THE REMAINDER DIES AND ROTS. THIS IS ACTUALLY A WASTE OF A VALUABLE RESOURCE AND EFFORTS NEED TO BE MADE TO EDUCATE FOREST OWNERS TO EFFECTIVELY MANAGE THEIR WOODLOT AND FOREST HOLDINGS

OF COURSE YOU AS A MEMBER OF YOUR COMMUNITY DERIVE BENEFIT FROM CLEAN AIR AND

WATER AND A MEASURE OF QUIET WHICH FORESTS PROVIDE. BUT YOU ALSO PROBABLY ENJOY THEM EQUALLY AS MUCH BECAUSE THEY ARE PLEASING TO LOOK AT AND PROVIDE OPPORTUNITIES FOR A VARIETY OF RECREATIONAL ACTIVITIES SUCH AS BIKING, HUNTING, AND CAMPING.

NOW LET US TURN OUR ATTENTION TO FARMS AS A PART OF THE UPLANDS. HOW WELL DO YOU KNOW THE PRODUCTS OF CONNECTICUT AGRICULTURE? ON GUIDE SHEET # 8, WE HAVE LISTED PRODUCT CATEGORIES OF AGRICULTURAL GOODS PRODUCED IN CONNECTICUT. TURN OFF THE RECORDER AND TRY TO NAME SEVERAL FARM PRODUCTS IN EACH CATEGORY. (PAUSE) G.S. #8

WELCOME BACK! DID THE VARIETY OF FARM PRODUCTS SUPRISE YOU? IT IS APPARENT THAT CONNECTICUT'S FARMERS PRODUCE A LARGE VARIETY OF CROPS AND MOST OF THESE CROPS ARE PERISHABLE GOODS. ON GUIDE SHEET #9 YOU WILL FIND A PARTIAL LISTING OF THE DIFFERENT CROPS AND ANIMALS GROWN BY CONNECTICUT FARMERS. WOULD YOU HAVE GUESSED THAT ALL OF THESE AGRICULTURAL PRODUCTS WERE GROWN IN OUR STATE? G.S. #9

ALTHOUGH FARMING IS AN INTEGRAL PART OF CONNECTICUTS CULTURAL HERITAGE, THE THIN, ROCKY SOILS AND HILLY TERRAIN HANDICAP LOCAL FARMERS WHO HAVE TO COMPETE WITH THE MORE FERTILE FARMS OF THE MIDWEST. CONSEQUENTLY, THE CONNECTICUT FARMS WHICH SURVIVE TODAY ARE THOSE WHICH PRODUCE PERISHABLE CROPS FOR LOCAL MARKETS. In slide # 12, you see a local farm stand selling Connecticut produce. Farm land still occupies ABOUT 18% OF THE STATE'S LAND AREA, AND SALE OF FARM CROPS PRODUCES AN ADEQUATE INCOME, IN FACT, CONNECTICUT FARMS OUT PRODUCE ALL OTHER NEW ENGLAND STATES ON A PER ACRE BASIS. IN 1972, CONNECTICUT'S TOTAL CASH INCOME FOR CROPS, LIVESTOCK AND POULTRY PRODUCTS WAS OVER $160 MILLION DOLLARS. ON GUIDE SHEET # 10 PART A, THE DISTRIBUTION AND APPROXIMATE ACREAGE OF CONNECTICUT FARMS IS SHOWN. AS YOU LOOK AT GUIDE SHEET # 10, NOTE THAT THE LARGEST AMOUNT OF FARMLAND IS LOCATED IN THE EASTERN AND WESTERN UPLANDS OF THE STATE. (PAUSE) THE CIRCLES INDICATING THE RELATIVE ACREAGE PER COUNTY ARE SUBDIVIDED INTO WOODLAND, CROPLAND AND PASTURE LAND PORTION. YOU MAY WANT TO STOP THE RECORDER WILL YOU STUDY THIS CHART OF AGRICULTURAL LAND USE. (PAUSE) Slide # G.S. #1

NOW LOOK AT PART B OF GUIDE SHEET # 10. THIS PART OF THE GUIDE SHEET CONTAINS INFORMATION ON THE VALUE OF FARM SALES. NOTE THAT THE CIRCLES ARE SUBDIVIDED THIS TIME. THE SECTIONS OF THE CIRCLE INDICATE THE RELATIVE PROPORTION OF LIVESTOCK AND LIVESTOCK RELATED SALES AND CROP SALES. DO YOU SEE ANY RELATIONSHIP BETWEEN THE RELATIVE AMOUNTS OF LAND USED IN PART A AND THE LIVESTOCK VERSUS CROP SALES ON PART B OF GUIDE SHEET # 10? (Pause) Now look at slide #13. THE EASTERN AND WESTERN UPLAND FARMS ARE MOST HEAVILY INVOLVED IN LIVESTOCK OPERATIONS. MUCH OF THEIR LAND MUST BE USED FOR FEEDING AND PASTURE OF THEIR LIVESTOCK. MORE INFORMATION ON THIS ISSUE CAN BE OBTAINED FROM THE DETAILED BREAKDOWN OF FARM PRODUCT SALES PRESENTED IN GUIDE SHEET # 12. ONCE AGAIN, WE CAN SEE THAT SALES OF LIVESTOCK AND DAIRY PRODUCTS ARE GREATEST IN THE EASTERN AND WESTERN UPLANDS WHILE SALES OF VEGETABLES AND FRUITS ARE GREATER IN THE CENTRAL LOWLANDS. THE VARIETY OF VEGETABLES, FRUITS AND BERRIES GROWN REFLECT THE NATURE OF MUCH OF CONNECTICUT'S FARMING INDUSTRY, WHICH, AS PREVIOUSLY NOTED, PRODUCE PERISHABLE CROPS Slide # G.S. #1

FOR LOCAL MARKET. YOU MAY BE INTERESTED TO KNOW THAT CONNECTICUT'S ONLY MAJOR EXPORT CROP IS TOBACCO, WHICH IS GROWN IN NEW HAVEN AND HARTFORD COUNTIES. ON GUIDE SHEET 11 PART A THERE IS A TABLE SUMMARIZING CONNECTICUT'S AGRICULTURAL PRODUCTION AS A PERCENTAGE OF CONNECTICUT'S CONSUMPTION . CONNECTICUT'S FARMS PRODUCED 20% OF THE DAILY PROTEIN NEEDS OF THE STATE'S POPULATION. BECAUSE MUCH OF CONNECTICUT'S FOOD IS GROWN CLOSE TO THE MARKET, THE FOOD IS RELATIVELY INEXPENSIVE, AND FRESH. IN ADDITION TO THE IMPORTANCE OF FRESH, LOCALLY PRODUCED CROPS, ANOTHER VALUE OF PRODUCING FOOD WITHIN A LOCAL MARKET REGION IS THAT AGRIBUSINESS CAN BE ENERGY EFFICIENT. SINCE THE FARM IS CLOSE TO THE MARKET, LESS ENERGY IS REQUIRED TO BRING THE LOCAL PRODUCTS TO MARKET THAN IMPORTED PRODUCTS. ALSO FOOD DELIVERY IS LESS VULNERABLE TO NATIONWIDE ENERGY SHORTAGES, TRANSPORTATION STRIKES AND GENERAL SPOILAGE.

G.S. #11

THE ECONOMIC VALUE OF FARMS IS MANIFESTED IN JOBS ON THE FARM, IN SUPPORT INDUSTRIES AND IN SERVICE INDUSTRIES. FARM LAND IS ALSO TAXABLE LAND AND PROVIDES INCOME TO TOWN GOVERNMENTS.

PERHAPS, THE MOST IMPORTANT NON-FOOD PRODUCING SERVICE PROVIDED BY FARMS IS THE MAINTENANCE OF THE HYDROLOGICAL CYCLE, WHICH PROVIDES US WITH WATER WE NEED FOR HUMAN ACTIVITY. THE CONNECTICUT PLAN FOR CONSERVATION AND DEVELOPMENT INDICATES THAT THE AVAILABILITY OF FRESH WATER TENDS TO BE A LIMITING FACTOR ON MAN'S ACTIVITIES. FARMS, EITHER IN WOODLOT PASTURE OR UNDER CULTIVATION HELP MAINTAIN LOCAL WATER SUPPLIES BY ABSORBING PRECIPITATION AND TRANSFERRING IT TO THE GROUND WATER SYSTEM, AND TO BROOKS, PONDS, AND LAKES. OFTEN LARGE PORTIONS OF A WATERSHED ARE COMPOSED OF AGRICULTURAL ACREAGE. THE LOSS OF THESE AGRICULTURAL LANDS TO HIGH DENSITY USE COULD ADVERSELY AFFECT THE ENTIRE HYDROLOGIC SYSTEM AND ENDANGER THE WATER SUPPLY FOR COMMUNITIES IN THE REGION.

AGRICULTURAL LAND PROVIDES OTHER, GENERALLY OVERLOOKED BENEFITS. AGRICULTURAL LAND CAN FUNCTION AS A POLLUTION TREATMENT SYSTEM. THIS ABILITY CAN BE EXPECTED TO INCREASE IN IMPORTANCE AS THE POPULATION INCREASES. THE POLLUTION TREATMENT FUNCTIONS CAN BE CATEGORIZED INTO FOUR AREAS. AS MORE AND MORE SEWAGE TREATMENT PLANTS ARE BUILT TO MEET THE NEEDS OF A GROWING POPULATION, THE DISPOSAL OF NUTRIENT LADEN SLUDGE WILL BECOME A MAJOR PROBLEM. ONE ALTERNATIVE WAY OF DISPOSING OF SLUDGE IS TO TRUCK IT TO FARMS WHERE IT CAN BE USED AS FERTILIZER. THIS PROCEDURE WOULD REDUCE THE NEED FOR EXPENSIVE INORGANIC FERTILIZERS WHILE SOLVING A MAJOR SOLID WASTE PROBLEM.

TERTIARY SEWAGE TREATMENT TO REMOVE PHOSPHATES, NITRATES, AND OTHER NUTRIENTS IS EXPENSIVE. BUT PURIFICATION BY FILTRATION THROUGH A SOIL CROP FILTER REMOVES NUTRIENTS CHEAPLY, GROWS A USEFUL CROP, AND RECHARGES GROUND WATER SUPPLIES. SEVERAL TOWNS ARE CONSIDERING UTILIZING ADJACENT FARMS TO FILTER THEIR SEWAGE EFFLUENT. EXPERIMENTS TO DATE INDICATE THAT THE SYSTEM IS VERY WORKABLE.

SIMILAR TO FORESTS, AGRICULTURAL LANDS TRAP AIR POLLUTANTS SUCH AS OZONE AND SULFUR dioxide. Vegetation is also an effective filter for particulate matter.

Another area in which agricultural land has a beneficial effect involves agricultural land as open space. Open space woodlots and crops in general, reduce noise pollution by acting as buffer zones.

Farms are also a valued and aesthetically pleasing part of the New England countryside. Because farms are frequently located on the edge of urban sprawl, many of them form a buffer zone between the city and the countryside. In this capacity they provide a welcome scenic relief which helps alleviate the urban landscape scene.

In addition to the values discussed already, agricultural land has value as open space, as recreation land, as a contribution to our aesthetic and scenic experience and for its part in preserving our historical and cultural heritage. In other words, farms are an integral part of the natural resource we know as Connecticut countryside.

Now look at slide # 14. (Pause) Here in slide #14 you can see an area where housing developments have been built on agricultural land. In the top of the slide, a small area of farm land still remains. Unfortunately for all their value, agricultural lands are disappearing rapidly. The charts on guide sheet # 11 part B document the loss of farm acreage in three Northeastern states. Slide #1 G.S. #11

Between 1949 and 1971 - twenty-two years, Connecticut and Massachusetts have lost 62% of their farm acreage. Approximately 1 million acres per state, part C and D of guide sheet # 11, documents the decrease in number of farms in three selected New England States. Turn the recorder off while you study guide sheet # 11. (Pause)

Although many of Connecticut's farms are economically successful, there are many problems and pressures which have caused Connecticut farmers to sell their land. The problems of Connecticut's farmers are caused by external, social and economic factors over which individual farmers often have little control. The most obvious, and perhaps most important, is the rapid rise in the dollar value of land. Competition for land is intense. The demand for a limited supply of land is high. Market values for some land in Connecticut has risen 100 percent between 1967 and 1974. This places tremendous pressure on farmland, particularly on those farms near growth areas of the state.

Closely related to rising land values is the issue of property taxation. In 1973 the Connecticut legislature had the foresight to pass P.A. 490 to provide use taxation of open space. Taxes levied on land is based on actual use. Most land in Connecticut is taxed at highest or best potential use. Best use means highest economic use. Under P.A. 490, farmers and other owners of open space may apply for a use-value assessment which can mean a significant reduction in land tax. The reduction in property tax has helped many farmers stay in business. But this is only part of the story. Participation in the P.A. 490 program depends on towns' participation in the statewide program. Unfortunately not all towns participate. In addition to land taxes, a big tax bite often comes on farm buildings and equipment. Many local assessors make up some of the loss in reduced land tax revenue by assessing the buildings, equipment and occasionally certain farm animals.

The inheritance tax is also a major factor in the maintenance of integral farms. Farmers with children interested in continuing the business must plan carefully to avoid crippling federal and state inheritance taxes. Part of the problem is that most assets of the farmer are not in cash. The inheritance tax is on all assets. In order to pay the tax, spouses or children are frequently forced to sell land or equipment to raise money to pay the tax. This leads to smaller divided farms.

Farm profits, in recent years, have been squeezed by increasing feed prices and higher labor costs. In order for a dairy farmer to make a modest income is necessary to have a minimum herd of 80 - 100 cows. Unfortunately, a herd this size requires an additional employee to manage the herd properly. For those farmers with fewer cows, outside income is necessary. Declining profits have meant increasing pressure to sell land for a premium price to reap a profit.

Another serious problem for the state's agricultural industry is the availability of labor. For orchard owners, the most serious factor threatening their existence is the lack of laborers to harvest and package fruit. In the last five years, little local farm labor has been available. In order to harvest their crops, labor is often imported from Jamaica or other countries. Short term labor is one aspect of the labor problem. Finding skilled farm help for long term employment is increasingly difficult and expensive.

Another factor, though less of a problem, has made existence tougher for farmers. This is the new public concern over environmental degradation and new environmental regulations. The problems of disposing of animal wastes, stream siltation from cultivation, pesticide side effects and nitrogen phosphate contamination of nearby bodies of water by fertilizers are significant environmental issues. The regulations designed to deal with these problems have reduced farm yields, increased costs and increased the red-tape farmers must contend with.

Interestingly, the farmer's new suburban neighbors have become one of their most aggravating problems. The new residents suddenly feel that their "rights" are impinged upon when they encounter a slow tractor on a road, the smell of fresh manure wafts across their property, or tractor noise disturbs their weekend tranquility. These new neighbors are often in the forefront, proposing new local ordinances that interfere with necessary farming activities.

The next part of the unit will involve the use of guide sheet # 13 and 14. Guide sheet #13 is an article entitled The Vanishing Land. The article has been published as a Connecticut Conservation Association White Paper. It is an eloquent and well documented case for action to preserve Connecticuts Agricultural Land. On guide sheets # 14 you will find an activity to accompany the article. Be sure to read the activity G.S. #13 & #14 on guide sheet # 14 before reading The Vanishing Land. Turn the tape recorder off while you read The Vanishing Land and complete the activity on guide sheet #14. (Pause)

As I read the Vanishing Land, I also worked out the activity on guide sheet # 14 . . . if you want to compare notes, you will find my results on guide sheet # 15. If you want some time to study my responses, turn off the recorder . . . (Pause) #15

In recognition of the issues so forcefully presented in The Vanishing Land a statewide commission was appointed by the Governor in 1974 to study the problems of agriculture in Connecticut. A summary report of the commission, known as the Governor's Task Force for the Preservation of Agricultural Land, is included as guide sheet # 16. G.S. #16 As you read the report, compare the statements and recommendations of the task force with the list of problems and suggested solutions list you made as you were reading The Vanishing Land. Turn off the tape recorder while you read the Governor's Task Force report . . . When you finish reading the report, turn the recorder back on. (Pause)

As you reviewed the alternative policies presented by the task force on the last page of the report, did you find an alternative which you feel would provide an equitable procedure for preserving agricultural land? Do you feel there is a better alternative? If so, write it down and use it for discussion later! How would you finance a program designed to preserve agricultural land?

In summary, we might point out that, while not nationally important, Connecticut's farms do constitute an important aid to the state's economy, and, additionally, the farm production offers an important local food source in view of the possibility of future food and energy shortages. The remaining farm acreage is endangered by increasing urbanization and economic pressures.

You may now be aware that such upland areas as farms and forests are valuable. In fact, they constitute an important resource. Like any resource, their use should be carefully planned and managed. Unfortunately, some of the most valuable of these natural resources are rapidly disappearing, the victims of urban sprawl and economic exploitation. Each year more farms go out of gusiness. They are sold off to industrial and housing developers or land speculators. Farmland is good quality land which can be readily utilized for development. The developments in turn can provide solid benefits in the local area both in tax returns and employment.

Most modifications of upland areas have a negative effect upon the natural functions of the upland ecosystem. A summary of activities carried out in upland areas and their impact is presented in the form of a matrix on guide sheet # 17. Stop the recorder while G.S. #17 you study guide sheet # 17. . .

Well, we have considered forests and farms in upland areas . . . Because upland areas are so simply and irrevocably converted, convincing reasons must be forwarded

IN SUPPORT OF THEIR CAREFUL MANAGEMENT AND/OR PRESERVATION. IN SHORT OF WHAT USE ARE UPLAND AREAS? OF WHAT USE IS A FOREST OR FARM? UNDER WHAT CIRCUMSTANCES ARE THE HOUSING AND INDUSTRIAL NEEDS OF THE STATE GREAT ENOUGH TO WARRANT THE LOSS OF THE UPLAND AREAS INVOLVED?

WE HAVE SUMMARIZED MANY OF THE VALUES OF UPLANDS - BOTH FARM AND FOREST ON GUIDE SHEET # 18. THE LIST OF ESSENTIAL FUNCTIONS THAT UPLANDS PERFORM IS EXTENSIVE. BEFORE YOU TURN THE RECORDER OFF TO READ THE FINAL GUIDE SHEET, REMEMBER, THE AESTHETIC VALUE OF FARMS AND FORESTS ARE BEST EXPERIENCED RATHER THAN DESCRIBED. PLAN TO TAKE A RELAXED DRIVE THROUGH THE COUNTRYSIDE AND EXPERIENCE FIRST HAND THE REAL VALUE OF CONNECTICUT'S UPLANDS.

THANK YOU FOR JOINING US.

TURN THE RECORDER OFF AND REVIEW GUIDE SHEET # 18. G.S. #18

Welcome to the audio-tutorial unit on aerial photography. In this unit, we will work together to develop your ability to read and interpret aerial photographs. Later in the unit, we will use the aerial photographs to update planning maps. In addition, we will see how aerial photographs can be used as a planning aid in making land use decisions. Before proceeding with the unit, turn the recorder off and review the objectives and instructions on guidesheet #1. (Pause) G.S. #1

Look at guidesheet #2. (Pause) Guidesheet #2 contains a reproduction of a topographic quadrangle map. This topographic map is similar to the one used in the map reading unit. The map on G.S. #2 does not have the color coding system of a regular topographic map. The colors have been deleted by the reproduction process. G.S. #2

While the map is informative, it does not contain as much information about this area as we might like to have, if we were employed as planners. Since the map represents an urban area most of the buildings or other land uses are not represented on the topographic map.

A planner interested in working on a project in this area might turn to a pictorial representation called an aerial photograph. Guidesheet #3 contains a standard aerial photograph used by many planners.

Aerial photographs utilized by planners are generally black and white and are taken by a camera mounted in the floor of a fixed wing aircraft. The plane flies in a constant direction and at a constant altitude above mean ground level, generally less than 10,000 feet. The photographs may be taken vertically, that is, with the camera pointed directly at the earth's surface, or obliquely, that is, with the camera pointed at a pre-determined angle of departure from vertical.

The State of Connecticut is completely covered by mapping quality photographs taken in 1970 at the scale of 1:12,000. Some local areas are covered by more recent photographs, which may have been taken at a scale different from that of the complete coverage of the state.

To facilitate communication about locations on the aerial photographs, we have arbitrarily divided each aerial photograph into four quadrants. As you look at G.S. #3, you see that dividing lines have been drawn on the photograph. Normally quadrant lines and letters are not found on aerial photographs.

When I suggest that an object is located in section A, I am referring to the upper left hand section of the photograph. Section B refers to the upper right hand section, while sections C and D are the lower left and right hand quadrants respectively.

G.S. #3 The dominant feature of the aerial photograph or guide sheet #3 is the airport with its two runways. By inference, we might expect to find an airport terminal and hangar near the runway. If you look carefully you will see the terminal in section A at the left end of the diagonal runway. Notice the small planes parked near the terminal. (Pause) Look closely! Look at the opposite side of the vertical runway. In quadrant B, can you see a hangar and an airplane tie down area? (Pause) Now look at the area surrounding the airport. (Pause)

What are the land uses in the area? (Pause) Correct. The primary land use in the area is residential housing. Note the extensive housing in sections A, B, and C especially along the shoreline in sections A and C. From the information content of the photograph, can you suggest a potential environmental problem for this residential area? (Pause) Correct, noise. Noise is a significant environmental problem. The frequency of take-offs and landings determines the level of annoyance the airport creates.

Compare the information content of the photograph on G.S. #3 to the topographic map on guide sheet #2. (Pause) Note that the topographic map does not represent each house. Why do you think the houses have been left off the topographic map? On the original topographic map this area was colored red. As you recall, the color red on a topographic map indicates a built up area. Because of the large number of buildings in these areas each individual building is not represented by a symbol on the map.

To the planner, aerial photographs offer many advantages over other data forms. An aerial photograph, when properly taken, captures reality in every visible detail. By contrast, a topographic map, is selective and frequently generalized because of scale limitations. Thus, an aerial photograph, while it may contain more detailed information than you need, is more reliable and provides more useful information than a topographic map. The only major deficiency aerial photographs present is the absence of elevation information.

However, aerial photographs provide the planner with a permanent and unbiased record of all reality visible to the camera. Finally, since individual photographs are fixed in time, they provide the planner the facility for stepping backward in history as a situation may require. For example, "before and after" photographs of an area in which the environment has been misused by a developer might become essential evidence in a court case. Or, a zoning decision could, conceivably, be based upon evidence of a particular condition having existed in the past.

Compare the size of the airport on the reproduced topographic map with the size of the airport on the aerial photograph. (Pause) The airport on the aerial photograph is larger...it is larger because of a difference in scale between the map and the aerial photograph.

In the unit on maps and mapping, we are told that topographic maps are generally drawn at a scale of 1:24,000. The vertical aerial photographs we are using in this unit are taken at a scale of 1:12,000. The ratio 1:12,000 means that one foot on the photograph represents 12,000 feet on the ground. Because there are some distortions of scale with changes in the altitude at which aerial photographs are taken, we will use scale to provide approximate distance on the earth's surface.

G.S.#3A

Look at guide sheet 3A. while keeping Guide Sheet's #2 and 3 in front of you. Measure the length of the diagonal runway on the topographic map. Then measure the length of the same runway on the aerial photograph. Write your measurements on G.S. 3A. (Pause) Finally, determine the relationship between the two measurements? If you wish, turn the recorder off while you perform these tasks. (Pause) Now compare your measurements to mine. The diagonal runway in the photograph is 4 inches long while on the map it is only two inches long. In other words, the length of the runway on the aerial photograph is twice as long as the representation of the runway on the map. This is consistent with the scale of the photograph being 1:12,000 and the map being 1:24,000. Because of the differences in scale, care must be taken in transferring information from the photograph to the map or vice versa.

Given the scale of an aerial photograph and a ruler, it is possible to approximate the size of real objects on the earth's surface. For example, the actual length of the runway in the aerial photo can be approximated from the scale of the photograph and our measured length of the runway in the photograph. Follow the exercise on guide sheet #3A part II. A scale of a:12,000 indicates 1 foot or 12 inches on the photograph represents 12,000 feet in reality. If 12 inches on the map is equal to 12,00 feet on the earth's surface, then one inch will equal 1,000 feet. We measured the length of the diagonal runway on the photograph as 4 inches. If 1 inch equals 1,000 feet, then the runway must be approximately 4,000 feet in length. Have you been able to follow the exercise II on guide sheet 3A. Stop the recorder and review the exercise. Then use the space provided on guide sheet 3A to approximate the length of the main or vertical runway shown in the aerial photograph. (Pause) How did you make out? According to our calculations, the main runway is approximately 5,750 feet long. The same procedure we have just followed can be used to approximate distances or size on the topographic map. The major difference is scale. On the topographic map 1 inch equals 24,000 feet, or 1 inch equals 2,000 feet.

Now let's take some time to compare the topographic map with the aerial photograph. The topographic map can provide important information which may not be obtained from aerial photographs of a given area. Locate the area in section D of the aerial photo on the topographic map. As you study the map, you will find that it indicates that section D in the aerial photo should have extensive marshes. Try to find the marshes on the photograph. Without the map information, would you have identified the marshes or would you have assumed the area to be dry open space? Can you find St. Bernadettes School on the aerial phot? Try locating St. Bernadettes school on the map. Then locate it on the aerial photo. Take some time to compare the map and the aerial photo. Try to locate the beach, the Nathan Hale School, the Nathan Hale park and a few other sites from the list at the bottom of guidesheet 3A. Try to locate them both on the map and the aerial photograph. Turn off the recorder while you carry out this activity. (Pause)

Now that you have learned to identify specific sites on an aerial photograph, let's turn to some more demanding tasks. Guide sheet #4 contains a complex aerial photograph which we will analyze by carefully assembling recognition clues. The recognition clues are outlined on guide sheet #5. (Pause)

G.S. #4

G.S. #5

Interpreting aerial photographs by features recognition and identification is difficult when first attempted, but becomes relatively easy as you acquire a "recognition vocabulary" through practice and experience. As is true with map reading, a series of recognition clues exist that facilitate the work of photo interpretation. In time, the sifting of evidence for a clue will become automatic; however, for the foreseeable future, you will need to make a conscious effort to insure that every possible alternative has been explored.

The characteristic of size, the first recognition clue on guide sheet #5 is sufficient to enable you or a photo interpreter to recognize many features on an aerial photograph. Certainly, you would never confuse an interstate highway with a secondary road, or a high rise apartment with a single family dwelling. Size must, of course, be interpreted in terms of the scale of the photograph. Once you become accustomed to dealing with scaled images, the problem of scale relationships largely disappears.

Section D of guide sheet #4 presents a good area for a study of size relationships. Try to locate the industrial complex in section D of guide sheet #4. It is relatively easy to identify the large industrial complex since the buildings in the complex are not the same size as the homes surrounding the complex. In this aerial photograph, we can identify and note the size of the buildings. In addition, we can detect air contaminants coming from the industrial smokestacks and moving toward the bottom right corner of the photo.

Shape is the second important clue for recognition of objects on a photograph. Anyone who has ever seen an aerial photograph of the Pentagon in Washington recognizes it again immediately. No clue other than the shape of the structure and the knowledge of its existence is necessary.

Similarly, less dramatic but more common shapes such as athletic fields can help us identify a school. In section C, you will see an oblong track and football field. Below the field on the photograph is a complex of buildings that comprise a high school campus.

The relationships which exist among sets of objects gives us another recognition clue called site and situation. Site and situation provide acceptable evidence for the identification of many objects. For example, the fact that a large building is visible in a photograph does not establish its identity. However, when an athletic field can be recognized in the adjacent area, the combination suggests a school complex. Similarly, large storage tanks located in a port area indicate oil storage facilities; while identical tanks away from the port, and at elevation, suggest water storage. Errors are possible when undue reliance is placed on evidence of site and situation, but the site and situation can help significantly in photo interpretation.

Contrast, or photographic tone as it is called by some experts, is a particularly valuable clue to the identification of certain features. Those objects that absorb light, such as water saturated soil, appear dark on an aerial photograph; whereas, those that reflect light, such as frozen ponds and concrete roads, are relatively light in tone. An experienced photo interpreter can, with a high degree of accuracy, use tone differences as an index for classifying roads and vegetation types, and for carrying out certain water quality studies.

Section C of the photograph on guide sheet #4 provides a good demonstration of how photographic tone can be used in identifying an area. Remember, objects which absorb light, such as water, appear dark. Notice the small dark circular area stradling sections A & C and the larger dark area which starts in section A and meanders down by the athletic field. The small circular area is a small body of water known as Beaver Pond. The large dark area is a body of water in Beaver Point Park.

The other recognition clues will be discussed only briefly at this point since they are not present in sufficient detail on this photograph. We will illustrate them as they arise on other photographs.

The texture of the photographic image, which is one indication of the nature of the object itself, assists in the differentiation of vegetation types, and in assigning agricultural land use categories. Effective use of texture as a clue for photo interpretation requires considerable experience: however, even the beginner can detect texture variation.

The presence of shadow on a photograph may be either a help or a hindrance, or both at the same time. Individual oil derricks, bridge columns, and industrial smokestacks that defy recognition by other means can often be identified by the shadow they cast. On the other hand, the shadow may so obscure detail at ground level that it becomes difficult to conduct an interpretation. Most aerial photography for analyric purposes is taken at midday to avoid shadows.

Relative elevation, drainage patterns and other topographic evidence are used by the skilled photo interpreter in evaluating soil conditions and delineating vegetation zones. In some situations, topographic evidence may combine with tone and other clues to indicate water conditions. When adequate evidence is available, professionally sound conclusions with respect to planning can be drawn.

For the recognition of many urban and physical features, pattern offers an important clue. Visualize for a moment the pattern associated with a suburban residential development -- the winding streets, two car garages, similarity of house configuration and, increasingly, the backyard swimming pool. All of these features can be distinguished on an aerial photograph and assist in the delineation of residential areas. Orchards, with the regular spacing of trees, are especially easy to identify on a photograph. Similar examples could be drawn from a list of physical features. For example, streams are classified by pattern, which is important in determining terrain conditions.

All of the above are clues to be used, but not abused, in interpreting an aerial photograph. Possibly more important than anyone of these to the planner or concerned citizen are local knowledge and experience. When the interpreter uses his accumulated knowledge and experience in conjunction with photographic evidence, the results are greatly enhanced. The significance of this statement will become increasingly apparent as you progress through the other units in the series.

On the bottom of guide sheet #5, we have arranged some additional clues in another fashion. In this section, the land use is identified first and then clues associated with it are noted. Both techniques have value in aerial photo interpretation. Choose the combination that makes you the best detective.

G.S. #6

Now turn to guide sheet #6. You may want to use the list of recognition clues from guide sheet #5 as we go through the exercise. (Pause 5sec.) Before we go any further, stop the recorder and spend a few minutes familiarizing your self with the aerial photograph. When you are ready to proceed, turn the recorder back on. (Pause)

The most dramatic feature in this aerial photo is the large interstate highway. Note the highway interchange in section C. Highway interchanges usually indicate that there is some commercial or industrial development in the area. The interchange empties onto a major feeder road. On both sides of this road, we find large buildings. These are probably commercial or industrial establishments.

In section A, try to locate the following: the meandering stream, (pause) the forested area around it, (pause) the large industrial building, (pause) the railroad tracks, (pause) a residential area, (pause) and an oval track (pause). Section B contains some residential land, but the most prominent feature is the golf course on the right side of the interstate highway in the upper corner of section B. The major recognition clue to this was the shape of the fairways and greens. Information from a topographic map confirmed our decision. Section C provides a contrast between old and more recent residential housing developments. Notice that the housing on the left hand side of section C is surrounded by thick heavy vegetation. (Pause) In contrast, the housing on the right hand side of section C has more open space, fewer trees and more lawns. Another clue to the relative ages of the housing areas is the grid like pattern of streets in the older residential neighborhood versus the less patterned more curvilinear streets of newer housing developments.

In section D we find another good illustration of pattern. Can you find an orchard or nursery in section D? The recognition clue is orderly rows of trees or shrubs. Such a pattern indicates an orchard or nursery. An orchard is located at the center of the top of section D. An on site visit confirmed our decision.

G.S. #7

Let's continue with guide sheet #7. (Pause) Begin by doing your own analysis of the aerial photograph. Keep notes on scrap paper of your identifications. We will make use of them in the next exercise. Turn the recorder off while you work. (Pause).

Let's compare notes on guide sheet $7. Section A and B are primarily composed of agricultural land. There is a major four lane highway going through sections C and D. The residential areas of section C appear to be relatively new when compared to the residential area in the right hand side of section D. The recognition clues used in reaching this conclusion were street pattern, distance between houses, and vegetation around the individual homes. At the intersection of sections A,B,C, and D there is a school. It was identified by its proximity to the baseball field. Another point of interest on this aerial photograph is the complex of apartments near the right hand edge of the photo, straddling the boundary between sections B and D.

By now, I am sure that you have observed the numbers in the upper left hand corner of each aerial photograph. For instance, as in this photograph, 3-1-70, 1426. 3-1-70 is the date of the photograph — March 1, 1970. The last four digits - 1426 - are an index number to help locate the aerial photograph on a base map. Do you have any idea why the photograph was taken in March. (Pause) Right. There are no leaves on the trees in March. Consequently, we can see more detail since the leaves will not camoflage objects from the photo interpreter.

If you want more time to study and interpret the aerial photograph on guide sheet #7, do this now. Then, turn to guide sheet #8, to complete the land use analysis activity. Turn off the recorder. G.S. #8

Welcome back! How did you make out? (Pause)

I am glad you did so well.

Why would a planner want to complete a land use analysis for this area? A detailed discussion of the rationale for land use analysis will be found in the cultural unit. However, a simple question will illustrate the point. If you lived in a residential neighborhood in section C, would you want a large industrial complex located near you? Would you want a recreation area such as a park located near you? Adjacent land uses do make a difference. Maps such as the one you just prepared fulfill that function.

Now that you have acquired some skills and experience at photo reading, we will give you a chance to exercise your abilities. Guide sheet #9 contains an aerial photo of an urban area. G.S. #9 Guide sheet #10 contains a series of questions and exercises. Turn off the recorder and complete guide sheet #10. (Pause). G.S. #10

While guide sheet #9 is in front of you let's look at some new recognition clues that we have not seen before. Did you identify the oil storage tanks in section D? This is a site and situation clue. The site is the harbor with tankers and tanks. Since the tanks are situated close to shore we conclude that these are oil storage tanks. Did you notice the tall buildings in section A? The length of the shadows cast by the buildings is a clue to their height. Did you notice how some of these seem to stick up at you? If you have not studied the clues for a central business district, focus your attention on section A and study the recognition clues. (Pause - 3 sec.) Finally, let us look at the city green in section A. There are three structures on the green. The tall steeples indicate the two upper structures are churches. What do you suppose the lower structure is? Could it be a church too? The answer is yes. But it is hard to tell! The clue that leads us to recognition is the shadow of the building. If you look at the aerial photograph closely, you will see the shadow of the steeple. Properly used, shadows can be valuable clues.

Aerial photographs can also tell a story. Look at guide sheet #12. (Pause) As you will hear many times in the Land Use Decision Making Kit and in articles in many states about land use planning, the loss of prime agricultural land is a critical problem. The aerial photograph on guide sheet #12 dramatically illustrates the cause of this loss. G.S. #12

Let's begin by studying section B. It is easy to see that once this was mostly agricultural land but has recently been converted to suburban, low density housing. We will discuss the problem of the loss of agricultural land in the Uplands Unit. You may want to refer back to this photograph when you complete the Uplands Unit.

Another concept that can be illustrated by an aerial photograph is differences in residential density patterns. Turn the recorder off and complete the activity on guide sheet #13. G.S. #13

How did you calculations go? My results were as follows: guide sheet #7, section C __________, guide sheet #7, section D__________, and guide sheet #12, section B________. Did you find the same results?

Your experience with aerial photographs would not be complete without an opportunity to utilize an aerial photograph for planning purposes. To give you some experience in the planning process, we have designed an activity in which you will assume the role of a planner in the highway department. Under the direction of the department of transportation, a series of surveys have been conducted to determine whether or not a new interstate highway is needed by the state citizenry Based upon survey information, the governor has concluded that it is necessary to build Interstate Highway 75. The highway will pass through the region shown in the aerial photograph on guide sheet #14. G.S. #14

Your task as the highway department planner is to select the best route for the highway right of way. Specific instructions for the activity can be found on the page opposite guide sheet #14. Turn the recorder off while you complete the activity. (Pause)

Welcome, back! How did you enjoy the role of a highway planner? (Pause) Compare your results in the hypothetical planning exercise to an actual decision rendered on the project.

The aerial photograph in guide sheet #14 was taken in 1930. On guide sheet #15 is an aerial photograph taken in 1975 of the same area showing a complete interstate highway through the area. Please note the two photographs are at different scales. How did your decisions compare with those of the State Dept. of Transportation? Based upon your present knowledge, would you modify the plan which was carried out by the state highway dept. in 1930? G.S. #15

We will use the subject of highways to examine one other aspect of aerial photography. Up until now, we have concerned ourselves with vertical aerial photographs. That is photographs taken with the cameras line of sight perpendicular to the earths surface. For most purposes, vertical photos are most useful. However, on occasion oblique aerial photographs prove to be of value? An oblique aerial photograph gives us a birds eye view of an area...It is taken on an angle rather than vertically. To classify the difference between the obique and vertical aerial photograph consider the following situations: an oblique aerial photograph is taken from the perspective of the pilot looking out of the front or side of the airplane cockpit or a standard aerial photograph from the perspective of an individual sitting in an airplane looking out the bottom cargo door straight down. Guidesheet #16 contains two oblique photographs. Compare the oblique photograph to the standard vertical aerial photographs shown on earlier guidesheets. Can you see the difference between oblique and vertical aerial photographs? To emphasize the difference compare the interchange in the top photograph on guide sheet #16 with the interchange in the vertical aerial photograph in guide sheet #16. (Pause) G.S. #16

Oblique aerial photographs are generally used for documentation and are not suitable for planning or mapping purposes.

The final topic covered by this introductory unit on aerial photographs is a discussion of the proper method for carrying out a photo interpretation. The initial requirement is a definition of the problem, with respect to both the subject to be investigated and the geographic area to be covered. After the problem has been defined, you should obtain as much information from non-photographic sources as possible in order to acquire the knowledge that will be necessary to proceed. If the geographic area to be investigated is one in which you live, or nearby, the task is simplified. Local government agencies, libraries and persons knowledgable about the area are all resources that can be exploited. Guide sheet #17 contains a suggested list of resources for your area. G.S. #17

Since you will normally be working with both maps and aerial photographs, it is recommended that you plot, either on the map or on a sheet of transparent paper placed over the map, the area covered by each photograph, indicating the photograph number for easy reference. When this has been done, a cursory examination should be carried out on all photographs. The purpose of the cursory examination is to familiarize yourself with the broad characteristics of the area, and to acquire a measure of confidence.

The detailed photo interpretation, which follows, may take either one of two forms. In the first approach, which is referred to as the "fishing" method, every item on the photograph is investigated, whether or not is seems to be relevant to the study. The advantages inherent in this approach are that it provides a safeguard against future surprises and enhances the quality of the final report. The primary disadvantage is that the method is slow.

The second approach is predicated upon probability. The photo interpreter proceeds directly to those areas in which the answer is apt to be found, and examines only this items of detail that are likely to contribute to the final answer. The advantage is that the method is fast. The disadvantages are that the photo interpreter must be relatively experienced and surprises are more frequent.

Photo interpretation has a broad application to land use planning, and is a technique that can be used effectively at the local level without the necessity of spending a large amount of money.

Thank you for joining us!

Coastal Wetlands

Slide #1

To the casual observer, the tidal marsh in slide # 1 might simply appear to be an uninteresting and valueless expanse of wetland. Close study however reveals an intricate and fascinating community of plants and animals intimately adjusting to an ever changing environment. This unique marsh environment is caused by the tides and mixing of the fresh water from rivers and streams, with the salt water of the sound or ocean. Probably no habitat is more complex to interpret.

Tidal ebb and flow brings about a fascinating zonation of plant life from the periodically flooded edge of the marsh to the upper marsh borders which are only occassionally flooded. In addition to characteristic grasses, beautiful wildflowers can be found in tidal marshes.

Slides #2 & #3

Coastal wetland animal life is just as spectacular. The water birds such as herons, ducks and rails nest and feed in these areas. East coast marshes also serve as important stops for migrating waterfowl on the Atlantic Flyway. Slides 2&3 show some of the organisms which are highly dependent upon coastal wetlands for part or all of their livelihood.

In addition to providing excellent plant and animal habitat, tidal marshes contribute significantly to the productivity of adjacent waters. From these marshes come the basic nutrients that start the food web, which ultimately supports the large number of fish and shell fish in surrounding waters. In this unit, we will explore how a tidal marsh is formed; we will study the characteristic grasses and wildflowers and the marshes diverse animal species. Finally, we will investigate the reasons for the enormous productivity of coastal wetland areas.

Before we begin our discussion in detail, it would be helpful to clarify four terms . . . estuary, estuarine marsh, salt water marsh, and tidal marsh. These four terms are listed and defined at the top of guidesheet #2 (Pause) Turn to guide sheet # 2 and study these terms. Stop the recorder while you carry out this activity (Pause 3 seconds).

G.S. #2

The sketch in the middle of guide sheet # 2 shows the relationships which exist among these coastal wetland areas. (Pause) Note the cattails in the sketch, these plants can grow in fresh water or water with low salt concentration. They are very common in fresh water tidal marshes.

The table at the bottom of guide sheet # 2 further explains the differences among coastal wetland classes. (Pause) The crucial difference is the concentration of salt in the water in these areas. The concentration of salt in the ocean and salt water marshes is about 35 parts per thousand. Estuaries and estuarine marshes have a salt concentration of 0.5 to 34 ppt., because in these areas the salt water of the ocean and the fresh water of the river mix.

G.S. #3
G.S. #4

Let's continue by discussing the formation of a marsh and its characteristic vegetation. Guide sheet # 3 shows a cross section of a salt marsh, while guide sheet # 4 has several pictures of common salt marsh plants (pause 3 sec.). Refer to these two guidesheets frequently during the following discussion.

Marsh formation begins on the edge of a bay or estuary. The shallow waters of the bay or estuary, offer plants the necessary requirements for active growth and maintenance throughout the growing season. These factors include warm water heated by the sun, nearly total light penetration due to the shallowness of the water, acceptable soils, and an excellent source of nutrients from the descending river, estuary and open sea.

These factors and the introduction of the primary colonizing marsh plants may lead to the formation of a marsh. Tall, smooth cordgrass with its high tolerance for salt has the ability to grow in a semi-submerged state. As a result, smooth cordgrass grows in a zone between the low and high tide levels and forms the base upon which the future marsh will be formed. Look at zone 2 on Guide Sheet #3 (Pause). The growth and death of plants and the accumulation of debris in the intertidal zone eventually raises the ground level to the point where it is inundated only during the last portion of the flood tide. In this manner, the original substrate becomes modified and permits the growth of salt meadow grass and spike grass. These plants prefer a drier and less saline environment than smooth cordgrass. Look at zones 3 and 4 on Guide sheet # 3 (Pause). In these sections of the marsh, where the organic matter is mixed with and covered by silt and fine mineral particles, air movement is prevented, and anaerobic decomposition occurs. Anaerobic decomposition is accomplished by bacteria in the absence of air. The process gives the marsh substrate its characteristic black ooze texture and a foul "rotten egg" smell. As the marsh surface increases in elevation, the number of floodings and the period of duration of each flooding decreases. This decrease in flooding limits the amount of salt and debris deposited on the area. This raised portion of the marsh includes the third and fourth zone of growth. Salt meadow grass grows in this area where the daily flood tides have an influence, but do not inundate the zone.

The zonation of smooth cordgrass and salt meadow grass shows up clearly in the photograph Slide #4
in the lower left hand corner of guide sheet # 4 (Pause 3 sec.) and on slide #4. When tide pools occur in zones three and four, glassworts, sea lavender, spearscale and marsh goldenrod are often found. The tide pools which form in open depressions on the marsh surface are unique, since they usually contain water of high salinity. . . sometimes exceeding 50 parts per thousand. This high salt level is caused by periodic flooding and constant evaporation of water. High salinity levels are restrictive to most halophytes or salt loving plants with the exception of the glassworts. Glasswort is shown in a photograph on Guide Sheet # 4 (Pause). These fleshy, translucent plants are usually found growing around the edges of tidal pools. As the marsh surfaces ages, tidal pools usually become filled with silt and debris and may then be colonized with salt meadow grass or other plants of the third or fourth zone.

The fifth zone of growth as seen on Guide Sheet # 3, is in reality a continuation of the previous zones, but lacks the influence of the daily flood tide. The elevation of zone 5 exceeds that of zone four by about 2 to 5 inches, and therefore restricts all tidal influence, other than the monthly highest tide. Due to the decrease in salinity and the usual presence of the fresh water table within 1 foot of the marsh surface, zones 5 and 6 have a specialized plant community containing species indicative of a zone of transition. In zones 5 and 6, we find black grass, switch grass and spike rush covering an extensive area and ranging from the marine to the (fresh water) portion of the marsh.

The upslope side of the zone of transition adjoins the upland where the only marine influence would arise from salt spray carried by prevailing offshore winds, and occasional storm tides. In the cross section on Guide Sheet # 3, this area includes zones 7 and 8. The plants found growing in this varied community encompass many plant families. Here we find reed, panic grass, cattail, bullrush, marsh elder, red maple and red cedar.

As we have discussed the formation of a salt marsh, we have indicated that the patterns of plant growth reflect different kinds of environmental conditions. In slide # 4 you can see plant zonation in a salt marsh. The two major environmental factors which influence where a particular plant may grow in the area which you see on slide # 4 are soil moisture and the amount of salt present within the soil. Each set of conditions and the needs of specific plant species are closely related. The result is the formation of distinct plant patterns or plant zones on tidal wetland. The distinct plant zones have been used by legislatures in defining the boundaries of Tidal wetlands. The role of wetland plants in coastal wetland classification and legislation will be covered in more detail when we discuss the regulation of tidal wetlands. Turn the recorder off and spend a few minutes studying guide sheet 3 and 4 so that you will be familiar with the different zones in the tidal marsh and representative plants which may be found in these zones. Slide #4

Based on the work of John Clark and our knowledge of how a tidal marsh forms and develops we can begin to define major ecological principles which underlie decisions on the management of coastal areas.

The salinity of coastal waters reflects a complex mixture of dissolved salts, the most abundant of which is common salt, sodium chloride. Earlier on Guide Sheet # 2, we talked about salt concentration in the ocean, coastal wetlands and estuaries. As you will recall, ocean water typically contains about 35 parts of salt per thousand parts of water. Salinity throughout the coastal ecosystem fluctuates with the amount of dilution by river inflow. In most coastal areas, there is a gradient in salt concentration that starts with high values of 30 to 35 ppt along the outer coast and drops to zero ppt at some distance up tributary tidal rivers.

On Guide Sheet # 5 there is a chart that presents information on the salinity tolerance of selected coastal wetland flora and fauna. Some coastal species on Guide Sheet # 5 tolerate a wide range of salinities, while others require a narrow range to live and reproduce successfully. Some species require different salinities at different phases of their life cycle. These special salinity needs are met by regular seasonal salinity changes caused by spring runoff, summer drought, etc. As you study Guide Sheet # 5 note the range of salinity tolerance characteristic of some estuarine plants and animals. (Pause) Most of those with a narrow salinity tolerance can withstand exposure to a much higher or lower salt concentration for a short period of time. As with other organisms, coastal plant and animal species have evolved over the years in harmony with their environment and have adapted to the natural changes which occur in salt concentration. Here is an ecological principle worth remembering. Natural fluctuations in salinity provide for optimum coastal wetland G.S. #5 ecosystem function.

It will be useful for later discussions to keep a record of major coastal wetland ecological principles as we describe them. A blank piece of paper on Guide Sheet # 6 can aid you in keeping your list (Pause 3 sec). G.S. #6

The first pinciple to record on Guide Sheet # 6 or your blank piece of paper is: Natural fluctuations in salinity provide for optimum coastal wetland ecosystem function.

Now, let us turn our attention to the productivity of coastal wetlands. Unfortunately, few people realize that tidal marshes and estuaries include some of the most productive acreage on the face of the earth. The tonnage of vegetation that the marsh produces per acre each year is unrivaled by any other natural soil. Furthermore, the growth takes place naturally, with no investment of human energy or natural resources. If coastal wetlands are so productive, why aren't they commonly recognized as productive agricultural land? (Pause 2 sec.). The major reason that the productivity of coastal wetlands is overlooked is that the crop is not directly exploited by man, but instead is recovered as high protein food from fish, shellfish and, to a minor extent, wildlife that derive their nourishment at least indirectly from the marsh as is illustrated on slide #5. Slide #5

In evaluating the productivity of coastal wetlands, we must not overlook the fact that the tidal channels which flow through them provide the spawning and nursery grounds for such important game and commercial fish as the striped bass, blue fish, menhaden and flounder. As adults these fish live in deep water, but they return to the coastal wetland to spawn.

Many of the plants which grown in tidal marshes provide sources of energy or forms of shelter for a great variety of birds and mammals, as well as for invertebrates such as snails, mussels, barnacles and insects. In addition, huge quantities of marsh grass decompose providing nutrient salts necessary for the growth of organisms in the tidal waters. Guide sheet # 7A describes the exchange of nutrients between tidal marshes and the tidal waters. Stop the recorder while you study Guide Sheet # 7. Turn the recorder back on when you are ready to continue. G. S. #7

Now turn your attention to the lower illustration on Guide Sheet # 7 (Pause). This illustration shows how nutrients move through a marine food chain. The basic nutrients are consumed by microscopic plants and animals which, in turn, are eaten by young fish and shellfish. The small fish and crustaceans are eaten by larger fish. This transfer of food energy from plants through a series of organisms is referred to as the food chain or food web. Stop the recorder and restudy Guide Sheet # 7.

Now that we have studied the productivity of tidal wetlands, let's try to convert some of our observations into ecological principles. These principles will provide a framework for understanding how organisms survive and interact with the forces and conditions of their environment. Ultimately, these principles can be used as a basis for a coastal zone management program. Guide Sheet # 6 will be used to maintain a continuing list of ecological principles for later use in developing management principles (Pause 3 sec.).

The primary ecological consideration in coastal management is control of water quantity and quality. This applies not only to coastal waters but to the upland drainageways and to the land surfaces. It implies that natural patterns of land vegetation and drainage should be retained in land development. Here is an important ecological principle to add to your list on Guide Sheet # 6. Water provides the essential linkage between land and sea elements of the Coastal ecosystem. . .

Water provides the essential linkage between land and sea elements of the coastal ecosystem.

Coastal waters are a mixture of fresh water from the land and salt water from the sea. The workings of the coastal ecosystem are influenced by characteristics of both sources of water supply. In a way, the two sources are in competition for the space within the enclosed water basins.

In the context of this competition the ocean water forces apply rather consistent pressure for estuarine space while the land based water forces apply more fluctuating amounts of pressure reflecting seasonal change in precipitation and runoff. For this reason, one looks to the land source-the watershed-for an explanation of intermittent or seasonal changes in such characteristics of the estuarine environments as salinity, circulation patterns and water contents. There is another reason to be concerned with the land sources-they are the ones we constantly alter and can most G.S. #8 easily control.

The amount of fresh water arriving in a particular coastal ecosystem varies seasonally.

The volume of the fresh water supply governs the salinity of all coastal waters. Salinity influences the types of species and their abundance and therefore the whole distribution of life throughout coastal waters - fish, shellfish, plankton, plants, and bottom fauna. Normally the salinity gradient established in an estuary fluctuates with the amount of river discharge.

The volume of fresh water inflow also governs the pattern of circulation of coastal waters through the rate of flushing of water basins and the strength of currents. In a stratified or two-layered estuary, the amount of runoff controls both the surface layer outflow and the bottom layer inflow. Circulation strongly influences the abundance and the pattern of distribution of life in the estuary.

Also related to volume is the amount of sediment, nutrient minerals, organic matter, and other substances dissolved or suspended in the water and carried down into the estuary. These materials have a strong influence on the quality of the coastal ecosystem because they affect plant production, oxygen concentration, and the fallout of sediments in estuarine basins. Nutrients supplied naturally via runoff are an important part of the energy budget of many coastal ecosystems.

The rate or schedule of the flow of fresh water into coastal waters is governed by many of the same factors that govern the volume of flow. The schedule of flow is important in its effect on the productivity, stability, and general health of the coastal ecosystem. The natural rhythm or pattern of seasonal flow is generally beneficial.

These are predictable seasonal variations in river flow into the coastal waters of the United States. The total volumes of inflow reflect the total amount of precipitation and the size and slope of the watershed. The detention characteristics of the terrain over which runoff waters flow enroute to the river channel are also important in governing the rate of delivery. The nature of precipitation also effects river flow. While rain moves directly into the hydrologic system as ground water or surface runoff, snow and ice may remain for months, subsequently causing an influx of many months' precipitation when it melts.

The above considerations lead to the following Ecologic Principle. Add it to your list. The natural volume, pattern and seasonal rate of fresh water inflow provides for optimum ecosystem function. .

Good circulation connotes good environmental conditions. A high rate of flushing, usually considered beneficial, provides transport of nutrients, cleanses the natural system and performs other vital functions. To some extent, good flushing also protects ecosystems stressed by development, because it hastens the dispersal and dilution of pollution. But, there is a limit beyond which the water passes too quickly through the system. For example, a large canal in southwest Florida forces water so rapidly through Fahka Union Bay that the mangrove system has a reduced opportunity to assimilate the nutrients in the water and to store them for use at times of slow discharge. Again it is a matter of balance and one must start with the presumption that the natural condition is best and should be maintained.

These considerations lead to another basic Ecologic Principle. Are you ready to write? Here is the principle. The natural patterns of water circulation within basins provides for optimum ecosystem function.

Sunlight is the basic driving force of the whole ecosystem as part B of guide sheet # 7 indicates. The fundamental source of energy for the growth of plants which in turn supply the foundation of nourishment for all life in coastal waters. For the ecosystem to function well, sunlight must be able to penetrate the water to a considerable depth so as to foster the growth of rooted plants and the phytoplankton that float beneath the surface. G.S. #7

Turbidity from suspended silt or from concentrations of organisms has a negative effect upon the amount of plant growth that can occur in coastal waters. In this way the growth of phytoplankton is self limiting. As the growth becomes denser the water becomes more turbid, thus decreasing the penetration of light into the water. Where light penetration is blocked by silt or by phytoplankton, there may be little growth occurring beneath a shallow surface layer. Estuaries are normally more turbid than ocean waters, being more silt laden and richer in nutrients and phytoplankton.

Light also affects the behavior of many animals. For example, many predatory gamefish are visual feeders and are benefited by good light penetration. Conversely, the tiny young stages of many coastal fish seek refuge in estuarine waters to escape predators. Neither extremely clear nor extremely murky water is totally desirable. It is necessary to prevent the addition of silt that would block light penetration, or of nutrients that would stimulate excessive plankton growth and lead to this same condition. This leads to yet another ecological principle. The natural variation found in light in a natural coastal wetland provides for optimum ecosystem function.

Temperature exerts a major influence on the coastal ecosystem. The occurrence of any one species and the mix of whole coastal water communities of life tend to vary from north to south with changing temperature. Many fluctuations of aquatic animals are temperature controlled; for example, migration, spawning, feeding efficiency, swimming speed, embryological development and basic metabolic rates are all temperature sensitive.

Temperature alteration-such as may be caused by plant effluents or changes in waterflow patterns - is particularly critical in estuaries because life is so concentrated, so many important species resort to estuaries for certain key life functions. The optimal temperature for any water habitat depends not only on the preferences of individual species but also on the well-being of the system as a whole. An ecological system is in dynamic balance and like a finely tuned automobile engine, any damage to a single component, can disable or impair the efficiency of the entire system.

In this case the relevant ecologic principle is as follows: the natural temperature variations which occurr in natural wetlands provide for optimum ecosystem function.

Of the various gases that are found dissolved in coastal waters, those of greatest importance in the web of life are oxygen and carbon dioxide, both of which occur in small but vital quantities. Animals use oxygen and produce carbon dioxide. Plants use carbon dioxide and produce oxygen. Therefore, each form can benefit from the other's work - one's waste is the other's need. There is a critical balance in the cycle between plants and animals that also involves transfer of dissolved gasses across the water surface to and from the atmosphere. Here we find an additional ecological principle. High concentrations of dissolved oxygen provide for optimum ecosystem function. There is little evidence to show that one need be concerned about harmful effects from excess oxygen in coastal systems.

Important chemicals in coastal waters fall into two classes: nutrients and trace-elements. The nutrients are vital to the whole chain of life in coastal waters because they are required by all plants, whether rooted plants or microscopic phytoplankton. In addition, they are very important because the animal life is supported by the plants. Free nutrient chemicals are relatively scarce in the waters of a natural coastal ecosystem because they are taken up rapidly by plant life. A supply of nutrients into the system by natural processes of runoff, rainfall, and other ocean sources, to replace losses and keeps the ecosystem functioning optimally. This natural supply is a critical need and one cannot expect to successfully substitute for nature by providing an artificial supply.

Nutrients are recycled in a relatively short time in coastal ecosystems. Marshes produce an excess of organic material. At the end of each growing season, marsh grasses are broken down by bacterial decomposers to produce detritus. This detritus is utilized directly as a food source by marsh organisms and is also washed into the coastal estuaries by fluctuating tides, what becomes basis for estuarine food chain. It has been estimated that two thirds of commercially valuable fin fish and shell fish spend part or all of their life cycle in salt marsh estuarine ecosystem and play an integral role in the complex food web of the estuary. The major plant nutrients that we are concerned about in the estuary and environment, are nutrients called nitrates and phosphates. The nitrogen content of plant tissue is much higher than that of the phosphates in plant tissue. In coastal waters the amount of available nitrate is generally believed to be the nutrient factor that controls the abundance of plants. Here then, is another basic ecological principle. Productivity in coastal waters is normally governed by the amount of available nitrogen.

The concept of primary productivity refers to the capacity of an ecosystem to produce basic plant material. Primary productivity is the amount of energy converted from light, nutrients and carbon dioxide to plant tissues. In terms of primary productivity, estuarine water bodies may produce 20 times as much as the deep sea and 10 times as much as either nearshore waters or deep lakes. Since primary productivity governs the ecosystem's total capacity for life, estuaries are generally more productive than the ocean.

Actual abundance of an ecosystem is a reflection of the productivity of that ecosystem. Table I on guidesheet # 10 illustrates the productivity of the estuarine ecosystems we have discussed. Even though the coastal wetlands and estuaries are only a small percentage of the ocean's area, they represent 50% of the annual fish production. By comparing actual abundance of life with potential abundance, an ecologist can determine if the system is malfunctioning and needs attention. G.S. #10

Energy needs of coastal ecosystems are met in two ways: first, from external driving forces and second, from internal supplies that are recycled within the system. The major external driving forces of coastal ecosystems are tide, ocean currents, river inflow, wind, sunlight and the basic inorganic nutrients that nourish plants and animals as slide #6 illustrates. The appropriate Ecological Principle here is: The flow and amount of available energy governs life processes within the coastal ecosystem. Slide #6

Internally, the chain of life - begins with energy assimilated by plants. Plants, the produce use the energy of sunlight in photosynthesis to transform carbon dioxide and basic nutrients into plant tissue, a form of energy which is available to animals as their basic foodstuff. The plants are then eaten and passed through the complex food web and back to basic nutrients. Guide sheet # 9 shows how this system functions. Because all animal food starts with plants, every organism ultimately depends on the major factors that limit the building of plant tissues, such as access to sunlight. G.S. #9

Storage capacity is also an exceptionally important aspect of coastal ecosystems. Storage is the capability of a system to store energy supplies in one or more of its components. Such a storage unit can be a stand of marsh grass, a fish school, a seed, organic sediment on the bottom of phytoplankton in the water of a bay. These units all gather and store a supply of energy that is in reserve against shortages.

Storage in plant tissues is particularly important because the reserve of nutrients stabilizes the system and provides a buffer against irregular heavy stresses or seasonal shortages. Storage is nature's hedge against boom-or-bust fluctuations of abundance and scarcity, according to the following Ecologic Principle. Here is another important addition to your list. A high capability for energy storage provides for optimum ecosystem function.

Estuarine vegetation is particularly important as a storage unit. For example, marsh grass

Slide #7. G.S. #10B in its entirety - roots, leaves, flowers, stems - provides storage upon which the regularity of nutrient supply to the estuarine food chain depends. Slide #7 is a cross-section of the tidal marsh grass, roots and soil. In addition, marshes have vast quantities of nutrient stored in their soils which provide an always available source of nourishment to the marsh grasses, as explained in part B of guide sheet # 10. Stop the recorder and read the paragraph on guide sheet # 10. When you are finished, turn the recorder back on.

In our discussion of the coastal zone, we have focused on the geographical unit that embraces all of the life and physical components of one distinct interacting shoreland and adjacent coastal waters. Ecologically, these relationships of living forms to their environment, has been the underlying concept of our discussions. Ecosystem orientation stresses that management of coastal water areas must be coupled with the management of adjacent shorelands and fresh water sources. This brings us to the final and probably most important ecological principle in our list: No one part of an ecosystem operates independently of any other.

This principle does not apply to the coastal ecosystem but to any ecosystem in the biosphere. All the parts of an ecosystem are linked together. It is impossible to operate any one independent of any other. This principle will apply to all our discussions on land use decision making in the other units.

G.S. #11 Up until now, we have concentrated on the natural value of an estuarine type of ecosystem that derives from confinement, salinity, circulation, tide, and nutrient storage. We have discussed how this leads to salt marsh formation and why the estuary is such a productive ecosystem. Guide sheet #11 summarizes the ecological principles we have discussed. Compare our list with the list you have been keeping. (Pause) Now, let's turn our attention to some of the other values of the coastal ecosystem.

G.S. #12 Take a look at guide sheet #12. Stop the recorder while you complete the activity on guide sheet #12.

In the coastal zone, there occurs an array of wildlife not readily evident to the man in the street. In the naturalist or careful observer, the marsh represents a fascinating diversity of waterbirds. To the hunter these offer exciting outdoor sport. And still others find these wetlands and the immediately adjacent waters a place where they can enjoy fishing, crabbing, claming and just relaxing.

Look now at slide # 8. Slide #8

Of the wildlife associated with the marshes, birds are the most conspicuous. Among those that breed in or are completely dependent upon the salt marsh for their food are the rails and sparrows. The rails are narrow-bodied birds, uniquely adapted for slipping between the dense vertical stems of the grasses and reeds. They feed on insects, snails and small crustaceans. Being elusive and retiring and most active in the twilight hours, they are seldom seen by the casual observer. Other birds nesting in the marshes include the song birds, black duck, blue-winged teal, common bittern, willet, marsh hawk, short-eared owl, red-winged blackbird, meadowlark and marsh wren. Besides these species, there are even larger numbers which are dependent upon the marshes and adjacent estuarine waters for food. Among these are the large spectacular wading birds - the great blue heron, the American egret and a number of smaller herons. The black skimmer, skims the shallow waters for small fish. In the spring and fall and during the winter months large numbers of migratory waterfowl breed in the far north and frequent the marshes. Among these are the many species of ducks and geese. The geese are grazers and are, therefore, highly dependent upon the roots and stems of the marsh grasses.

The food for this great diversity of bird life is derived either directly or indirectly from the marshes. Here upwards of twenty genera of marsh insects, eighteen genera of bivalves, and fifteen genera of crustaceans contribute not only to this avian food chain but also to man's prized shellfish resources. The small fish of the shallow adjacent waters, the killfish, minnows, and silversides are a vital part of this complex web of life. They serve several roles. They furnish a food source for this large and diverse bird population; they aid in reducing the population of mosquito larvae; and they may also become the prey of our larger fishes, thus contributing to our commercial and sports fishing resources.

Other animal life on the marsh includes the diamond-backed terrapin and several species of mammals. Muskrats and meadow mice inhabit the marshes the year round, and in some areas the muskrat Slide #9 is "harvested" for its fur. Other mammals frequently visiting the marsh include deer, fox, raccoon, skunk and opossum.

In this description, we have shown how the tidal marshes support one of our richest wildlife populations, intricately adjusted and interdependent upon the existing natural setting. Furthermore, it has been emphasized that the tidal marshes cannot be isolated as a specific ecological entity. Instead, we find a closely-knit interacting complex of habitats involving not only the marsh, but also the adjacent waters, the salt ponds, bays and estuaries.

Diversity expresses the variety of species present in an ecosystem. It is generally assumed that a high diversity of species both plant and animal is to a better eco-system balance and provides a greater resiliance to a catastrophic event such as disease or storms. Conversely a low diversity may indicate a stress system or one that has been degreated for example by pollution. The flora and fauna of a coastal system exhibit a rich diversity of species. Most ecologists agree that diversity tends to stabalize biological systems. A corn field is much less stable ecologically than a coastal wetland. In an artificially managed ecosystem such as a corn fields, man must add considerable energy in the form of fertilizer, pesticides, etc. to keep them productive and stable. Such is not the case with natural coastal wetlands.

Now look at slide #10.

Slide #10

Connecticut's coastline is constantly pounded by waves which are often intensified by coastal storms. By their nature though, coastal wetlands can considerably reduce the impact of these waves. As a wave moves toward the shore, it first encounters the tidal flats where much of its energy is diffused. It continues shoreward and encounters a barrier beach which absorbs most of the remaining impact - although some of the energy leaks through, via the natural inlets, into the estuarine/marsh system.

Some degree of interaction also occurs between the coastal waters and the contiguous freshwater marshes lying inland from the salt marsh. These freshwater marshes act as a buffer, protecting the inland from coastal flooding and the estuarine marsh area from adversely high levels of terrestrial runoff caused by spring thaws and inland storms.

The coastal wetlands act as a sponge, holding the excess water from extra high tides and excessive storm runoff. The natural storm buffer can be easily lost when the wetlands are filled for industrial or housing development. Once the wetland is filled, the storm water has no place to dissipate its fury except on the upland shore and its man-made structures. Often storm damages, as in the 1957 Hurricane, are increased because of extensive loss of coastal wetlands.

Coastal wetlands also perform another hydrological function. The wetlands, rich in micro-organisms, act as a pollution filter. The micro-organisms are able to digest many of the organic pollutants and convert them into an acceptable form to enter the food chain. Micro-organisms can also absorb excess nutrients and convert them to forms that can be utilized or stored. The functions of the coastal wetlands as a pollution treatment facility is often overlooked in valuing the wetlands.

Coastal wetlands and estuaries can serve as resource and study areas for scientific research and as outdoor educational exhibits -- living museums where the dynamics and ecological role of these ecosystems can be taught. In education, these outdoor laboratories can be used to emphasize such basic ecological principles as energy flow, the stability of diversity, recycling, and limited carrying capacity. All these are directly related to man and the environmental problems he has created by failing to recognize their pertinence to human ecology.

Now look at slide #11. Slide #11.

Wetlands also provide a great recreational outlet. Fishing and hunting are still important forms of recreation for many citizens. Others stalk the wetlands with binoculars, where the great diversity of waterfowl and spectacular waterbirds gives pleasure and inspiration. Wetlands can be incorporated into the untouched, open spaces of every town, thus becoming a part of our necessary commitment to open lands.

And finally, but not least in value, is the aesthetic value of coastal wetlands and estuaries as is illustrated by slide #12.
Scenery must be seen to be enjoyed, and the picture we carry in our minds of some beloved area such Slide #12
as that in this last slide, is based on outlooks from which the eye can take in at a glance a sweeping view of the landscape. Vistas require a certain amount of openess in the foreground such as is created by a meadow, a coastal wetland, or a body of water. The aesthetic value of the coastal zone should not be overlooked.

Somewhere between seven and fourteen thousand years ago the glaciers retreated across New England, leaving approximately 40,000 acres of salt-water tidal marsh along the Connecticut coast. Today about 14,000 acres of tidal marsh remains. More than half of the original marsh area has been destroyed by man's activity. The total of Connecticut's coastal wetlands includes these 14,000 acres of salt water marsh and an additional 5,000 acres of brackish and fresh water tidal marshes.

What has been the cause of tidal marsh destruction? Is there a single agency or groups responsible for destroying tidal marshes? A recent publication of the Fish and Wildlife Survey can help us answer these questions. A summary of the survey is reproduced on guidesheet #2. (Pause 3 sec.) While you are reading the guidesheet # 2 consider these two questions. What are the causes of the destruction of coastal wetlands and where is the destruction occurring? (Pause 5 sec.) Part B of the guidesheet indicates that the major cause of marsh destruction has been indiscriminate filling by private landowners. Significant losses have occured as part of programs planned and implemented by municipalities and the state for parks, roads or waste disposal. Our question about location of marsh destruction, is answered in Part C of Guidesheet # 2. G.S. # 2

From this data, we see that the greatest marsh destruction has occurred near heavily populated areas (5 sec.).

On guide sheet # 3, there are two maps which provide important information on the proximity of Connecticut's coastal wetlands to areas of intensive urban development. There are only two small sites on the entire Connecticut Coast which were not classified by the Interagency Water Planning Board as intensive urban development areas. Study both maps on Guide Sheet # 3 . . . locate a few of Connecticut's remaining coastal marshes on map A and determine whether or not the sites you select are in areas of intensive urban development by approximating their location on map B. Turn off the recorder while you carry out the activity. G.S. #3

Before discussing present land use decisions involving the tidal marshes, it may be helpful to develop a historical perspective on how man has interacted with coastal wetlands from pre-colonial settlement days to the present.

An insight into how past human activities have affected the present conditions of our marshes and estuaries might best be obtained by taking an in depth look into the history of one of Connecticut's important coastal marshes - The Quinnipiac River marsh.

The Quinnipiac marsh is a large estuarine marsh located in the valley of the Quinnipiac River. It was formed subsequent to the retreat of the Wisconsin glacier over 10,000 years ago. The marsh had been growing and changing, for thousands of years before man had his first impact on the marsh. The process of marsh formation and evolution is discussed in Part I of this unit.

The American Indian was probably the first human group to realize the abundance of food coastal wetlands had to offer. Indians hunted game within the marshes and on the river shores. They fished in the waterways and harvested edible plants. Since the coastal wetlands supplied so many of their needs, the Indians built villages near the coastal wetlands. Recent excavation at the site adjacent to the Quinnipiac marsh, called the Burwell-Karako site, has provided evidence that many different Indian tribes populated this coastal wetland area. Radio-carbon dating of material removed from the site indicates that it has been used intermitently for some 3,000 years.

Because of their small numbers, the effects of Indian settlements were negligible. Occasionally there were fires in the marsh, but it is not clear whether they were accidental or planned. It wasn't until the first European settlers arrived in 1637 that the human impact on the marsh became significant.

The settlement of the mouth of the Quinnipiac River illustrates a pattern that was repeated many times on the New England seashore. John Mason, while pursuing the Pequot Indians from a battle near Mystic, saw smoke in the area of the Quinnipiac River delta. He anchored and met a group of friendly Indians known as the "Quinnipiaks". As a result of observations made during his visit. Mason named the penninsula "Fair Haven" and recomended that a colony be started in this "new haven". The following year, 1638, John Davenport and Thedius Eaton led a group of colonists to "new haven" and, by bartering a few knives, spoons and scissors, secured a 100 square mile area of land from the Quinnipiacs. By agreement, the Indians were to live on a 1900 acre area on the east side of the river

As additional colonists arrived, they occupied the upland shores of the Quinnipiac marsh, harvesting vast quantities of grass from the open "salt hay" fields.

Slide 1.

The hay was used as forage, bedding, packing, roof thatching and mulch. Livestock also grazed on the marshes until the number of animals became too large to manage. After this point, cattle were put on upland pastures and the salt marsh hay was cut for feed. The hay was collected during the winter months when the marsh deposits were frozen and the hay could transported to shore. Often, the colonists burned the marsh after the hay harvest in an effort to control the investation of biting green head flies.

The marsh had never failed to provide the early settlers with a varied and abundant supply of fish and game. But, all of a sudden, the productivity of the marsh began to decline. The number of water fowl and shore birds declined in response to excessive hunting and habitat modification. Extensive areas. of the marsh became clogged with topsoil sediments which eroded from adjoining upland farms...overharvesting of the marsh grasses took its toll on the ability of the marsh to constantly renew itself. The marsh was no longer well protected by mats of dead grass. The changes that man had brought about interrupted the normal function and cycles of the coastal wetlands and their productivity declined.

At the beginning of the industral era in New Haven, the Quinnipiac Marsh and numerous local farms were being abandoned as a result of declining agricultural productivity. In the mid 1800's the railroad became the opening wedge which industry followed into the marsh. Today, the railroads, industry, commercial establishments and institutions encroach upon the marsh. On guidesheet # 4 there is an aerial photograph of the Quinnipiac marsh. The railroad yards still dominate the marsh in this area. G.S. #4

Let's utilize the aerial photograph on guide sheet # 4 to analyze man's impact on this tidal marsh. Take a close look at the aerial photograph on guide sheet # 4 . . . as you study the aerial photograph, see if you can locate the sites which are listed at the top of guide sheet # 5. Stop the recorder for the activity. When you have located all or most of the sites turn the recorder back on . . . (Pause 5 sec.) G.S. #5

As you checked off your observations of mass impact on the marsh, you simply identifed sites. Now let's examine the impact that man's structures and activities have on the marsh. To begin with, let's consider the impact the railroad yards. The track right of way covers a large land area in what was part of the Quinnipiac Marsh. The construction of the railroad complex involved a tremendous filling operation. Many acres of marsh were destroyed by the addition of fill to support the tracks. The roadbeds isolated many sections of the marsh from the flushing action of the tidal water. The impact of isolating sections of the marsh is often the same as filling that entire area. The isolation of these sections eventually caused changes in salt concentration of the marsh which lead to changes in vegetation.

We could go on making general statements, about the impact of the railroads or other man initiated changes on the marsh without necessarily coming to any coherent conclusions. But, if we think about the ecological principals outlined in part I of this unit, we may focus our thinking upon issues of real import. The ecological principals define the aspects of coastal wetlands that permit to function at optimal levels. These same principals form the basis for the coastal zone management rules which are outlined on guide sheet 5B. Read the list of management rules and then assess the impact which one or more of the man initiated changes listed at the top of guide sheet 5 has had on the marsh. Has the development of the marsh been conducted in accordance with the management rules? Stop the recorder while you read the management rules in section B and carry out thie activity in section C. When you are ready to continue, turn the recorder back on.

Proper management of coastal wetlands should be organized with these important management rules in mind. A serious effort should be made to maintain the structural, ecological and aesthetic integrity of these productive and vital resources.

Further insight into the reasons for coastal wetland destruction can be gained by looking at the way in which some people define the value of coastal wetlands. Turn to G.S. #6 guide sheet # 6 . . . Here you have two sets of statements on the value of wetlands. Turn off the recorder while you read these definitions. Turn recorder on again, when you are finished. (5 sec music). These definitions were listed in a state document explaining the need for public regulation of coastal wetlands. The list summarizes many of the things we have talked about in this unit. I am sure you have noticed the contrast between the common definitions and the uncommon definitions of wetland value. Which statements most accurately relfect your attitudes with regard to the value of wetlands?

Through the efforts of some concerned legislators, scientists, conservation groups and others, the Connecticut Legislature unanimously passed "An Act Concerning the Preservation of Wetlands and Tidal Marsh and Estuarine Systems" in 1969. This came to be known as the "Wetland Act" or Publc Act No. 695. The act gave the Commissioner of Environmental Protection a clear mandate to take the steps necessary to preserve Connecticuts tidal marshes. The Act clearly states that an immediate mapping and inventory be made of Connecticut's salt marshes. The term salt marshes is carefully defined in the Law. There are two major features which you should note:

1. First, to be considered tidal marsh, the land must be subject to tidal action, or it must be connected to tidal waters; and

2. Second, it must bear an association of plants characteristic of salt marshes, or have the capability thereof.

The definition is based on the vegetation of the marsh. It may be useful for you to review the plant species and distribution in Part I of this unit. The Tidal Marshes of Connecticut: A Primer of Wetland Plants published by the Connecticut College Arboretum is also an excellant resource for this purpose. It is listed in the bibliography.

Before proceeding any further, you should take time to read the summary of Public Act 695, presented on guide sheet # 7. Turn off the recorder while you study guide sheet G.S. #7 # 7.

Because the law is based on vegetation, the mapping required engineers and biologists to identify and stake the wetland areas in the field and then locate them on property maps. The task at times was not difficult since coastal wetland plants occur in zones with respect to mean tidal levels. The boundaries almost always correspond with the zone High tide bush and or switch grass. High tide bush occurs just at the level of the seasonal extreme high tide, when the surface of the marsh is inundated to a depth of about six inches. The switch grass zone corresponds with the level of occasional storm tides. The legal language takes advantage of plant zonation that we discussed in the first part of this unit. In case you are interested or may need the information in the future, a list of higher plants which form the dominant vegetation of salt marshes is presented on guide sheet # 8. Stop the recorder and review guide sheet # 8. When you are ready to continue, turn the recorder back on! (Pause) G.S. #8

The Department of Environmental Protection has nearly completed the program of inventorying and mapping the boundaries of the state's wetlands. Maps designating tidal wetlands are on file in each town possessing these areas within it's boundaries.

In Connecticut, the process of protecting the tidal marshes was a slow one. After [illegible]logists mapped the coastal wetland areas, the information was transferred by engineers to property line maps. Owners of affected property were notified by registered letter not less than 30 days before a public hearing on the boundaries. A hearing officer took testimony at the hearings of discrepancies, omissions, additions and appeals for exclusions. After the hearing adjustments of boundaries were made based on field checks and the hearing. Finally, the Commissioner of Environmental Protection issued an order establishing the boundaries which have been published as a legal notice in public hearings.

Once boundaries for coastal wetlands are legally determined, the act regulates the activities that can occur within those areas. Activities regulated by this act include, but are not limited to, draining, dredging, excavation or removal of soil, mud, sand or gravel from any wetland or the dumping, filling, or depositing of any soil, stones, sand, rubbish, and erection of structures, driving of piles, or placing of obstructions whether or not they change the tidal ebb and flow. No regulated activity may be conducted in any wetland without a permit, and any person proposing to conduct a regulated activity upon a regulated wetland must file an application for a permit with the Commissioner of Environmental Protection. According to the language of the act, the Commissioner in granting a permit must consider the effect of the proposed work on public health and welfare, marine fisheries, shell fisheries, wildlife, protection of life and property from flood, hurricane and other natural disasters and the general policies of the entire act.

Philosophically the law is well designed. Unfortunately, the Department of Environmental Protection lacks the personnel to monitor activities on every coastal wetland. As a result, citizen input is extremely important to complete the success of the act. Suspected violations of Public act 695 should be reported to the Department of Environmental Protection.

Once Public Act 695 became law, it was only a matter of time before the law would be challenged in the courts. The first major contest was not long in coming . . . since 1948, the Rykar Corporation of Stratford had been burying pieces of the Great Meadows Salt Marsh for future industrial development. The Great Meadows salt marsh is marked on the map of tidal marshes on guide sheet # 3 and is shown in slide #14. (Pause) Before the development of the marsh could proceed, the Rykar corporation had to contend with Public Act 695. Slide #14

In 1970, the Rykar Industrial Corporation filed an application for a permit to fill in the Great Meadows Salt Marsh in two stages to construct a deepwater port and an industrial park. The public hearing on the permit attracted wide attention because it called for the loss of 277 acres of a large healthy marsh and because it was considered a test of the strength of Public Act 695. Rykar claimed that since there was no Public act 695 in 1948, they should be allowed to develop the marsh. Rykar claimed the land was worth $150,000/acre as an industrial site. In addition, the new industrial park would provide taxes to the town of Stratford. If they were not allowed to proceed, Rykar assered that the state would be taking their land without compensation.

Opponents of the permit asserted that the Great Salt Meadows marsh was a healthy vital productive wetland that would be destroyed by filling. They claimed this was just the activity that Public Act No. 695 was passed to prevent. To support their assertion that this permit should be denied, they presented testimony on the consequences of the destruction of this marsh. Among the effects would be the destruction of the oyster beds, possible erosion by tides of recreational beaches, and the loss of a large area which entrapped sediments from upland erosion. When there is no marsh, the sediments run into the sea, filling in harbors and channels.

The climax of the hearing was provided by Edwin Coffin, representing the Army Corps of Engineers, who testified that if the marsh was filled in, the rain run off and its burden of sediment, could not be drained from the filled-in area into the sound, without complex engineering, the cost of which would have to be met by the Federal and local government. To replace the marsh, Stratford would need a hurricane barrier, a dike 12 feet wide and 18 feet high to protect the town from hurricanes. Of the 14 million dollar cost, $3.5 million would come from Stratford taxes.

In February 1971 the Commissioner of Environmental Protection denied a permit to Rykar. Following the denial, Rykar sued the State of Connecticut claiming an unjust taking of their land had occurred. They requested just compensation on an asserted value of $150,000 per acre or 42 million dollars.

The land use controls placed upon private land owners under this and other land use planning acts is a constant source of controversy. Significant discussion has occured on the distinction between public and private rights in property. The question of what kind of public control of private property constitutes a taking of an individuals land without just compensation is the source of continuing litigation.

In December 1973 the Superior Court in Hartford, in a complex decision upheld the permit denial but offered Rykar the hope that a revised application might be acceptable. The case is under further litigation. The Court of Common Pleas in another recent decision involving the wetland act stated that "The legislation is establishing the policy of protection for tidal wetlands based on the power of the state to promote the public health and welfare, recognized that it must be balanced against the common law right to free use of property . . ."

The court also concurred that a land owner should be entitled to some feasible and practical use of his property. Although specific exercise of police power does prevent the enjoyment of certain of the landowner's rights this does not necessarily constitute a taking without just compensation.

A more recent case has just been reviewed by the Connecticut State Supreme Court. An article, from the D. E. P. Citizen bulletin is a reproduced guide G.S. #9 sheet # 9 . The article describes the Brecciaroli case for you. Stop the recorder while you read guide sheet # 9 .

In arguing for the development of coastal wetlands emphasis is generally placed on the value of the land in question, and the income and tax revenues to be generated by the activity proposed for the wetland. Frequently the owners of the coastal wetlands and proponents of wetlands development fail to recognize the long term cost of developing these areas. The development of welands is marginally feasible at best! The initial cost of devlopment or site preparation, when combined with the long-range cost of maintenance and protection that these areas usually require, raises the cost beyond a reasonable level. Coastal wetlands must be drastically altered before any type of permanent structure may be located on them. The temptation to develop these areas will continue to exist since the initial price of the wetlands is low compared to the adjacent upland and the potential for a quick return is high.

The extensive alteration we refer to would include large-scale filling and dredging operations that will result in a number of liabilities that often outweigh the addition to the tax base of the community that the development would add. Some of these liabilities are listed on guide sheet #10.

1) Flooding in coastal wetlands often occurs as a result of a set of conditions in- G.S. #10 cluding the superposition of abnormally high tides, storm surge, seasonal storms, and hurricanes. Such flooding causes a high level of erosion of the exposed faces of land. If the marsh is filled, it will be necessary to install protective structures to alleviate this problem, but the structures themselves often cause additional problems elsewhere. In addition, maintenance of roads and utility lines through areas that are subject to flooding is quite often a continuous procedure, especially during the fall and winter seasons.

2) Soil conditions in marsh areas necessitate the use of filled areas for the

PLACEMENT OF SEPTIC SYSTEMS AND THE ATTENDANT LEACHING FIELDS. THESE SYSTEMS ARE SELDOM CAPABLE OF HANDLING THE VOLUME AND VARIETY OF TODAY'S SEWAGE, ESPECIALLY WHEN THE LAND USE IS CONCENTRATED. THE DEVELOPMENT OF WETLANDS WILL HASTEN THE TIME WHEN A COMMUNITY MUST INSTALL OR EXPAND A MUNICIPAL SEWER SYSTEM, NECESSITATING THE EXPENDITURE OF LARGE SUMS OF MONEY FOR THE TREATMENT PLANT AND THE ATTENDANT COLLECTION LINES AND PUMPING STATIONS. THE TIME SCALE INVOLVED IN THE INSTALLATION AND EXPANSION OF THIS SYSTEM WILL BE RELIANT ON THE SUITABILITY OF ANY LAND FORM TO DEVELOPMENT ALONG WITH THE CONCENTRATION OF THE DEVELOPMENT ITSELF.

3) GROUNDWATER SERVES AS THE WATER SUPPLY OF MOST COASTAL COMMUNITIES AND SOME PROBLEMS INVOLVED IN THE PROPER UTILIZATION OF THIS RESOURCE CAN BE READILY LINKED TO SEWAGE DISPOSAL. PRIVATE WELL SYSTEMS ARE OFTEN PLAGUED BY SALTWATER INTRUSION AND INEFFECTIVE SEPTIC SYSTEMS, ESPECIALLY IN OR ADJACENT TO WETLAND AREAS. THESE PROBLEMS NECESSITATE THE EXTENSION OF A MUNICIPAL WATER SUPPLY SYSTEM INTO AREAS PREVIOUSLY SUPPLIED PRIVATELY. MUNICIPAL SYSTEMS SUCH AS THOSE WE HAVE MENTIONED REQUIRE THE OUTLAY OF LARGE SUMS OF MONEY, OFTEN BEFORE THE COMMUNITY IS REALISTICALLY PREPARED TO MAKE SUCH A FINANCIAL COMMITTMENT.

ENVIRONMENTAL QUALITY AND LONG-RANGE ECONOMIC WELFARE GO HAND-IN-HAND IN THE COASTAL COMMUNITY. IT IS THE COASTAL RESOURCES THAT ATTRACT VISITORS AND POTENTIAL HOMEOWNERS TO THESE AREAS. THE DEGRADATION OF ANY UNIQUE LAND FORM OR THE UNEDUCATED USE OF ANY ECOLOGICALLY VALUABLE AREA WILL ULTIMATELY RESULT IN BOTH THE LOSS OF THE VIABLE AREA AND THE ULTIMATE DECLINE OF THE COMMUNITY. THE STATE AND FEDERAL GOVERNMENT CAN INSTITUTE WETLAND PROTECTION THROUGH LEGISLATIVE ACTION, BUT IT IS UP TO THE COMMUNITY AND ITS CITIZENS TO COMPLY WITH THESE REGULATIONS AND TO WORK TOWARDS ASSURING THE VIABILITY OF THE COASTAL RESOURCES.

BY NOW, IT IS OBVIOUS THAT FOR A LARGE VARIETY OF REASONS, BY EXERCISING HIS G.S. #10
RIGHTS OF OWNERSHIP, MAN HAS HAD A NEGATIVE IMPACT UPON COASTAL WETLANDS. MANY CON-
FLICTS HAVE ARISEN OVER THE VALUE OF COASTAL WETLANDS AND PATTERNS OF THEIR UTILIZA-
TION. ON GUIDE SHEET #10 THERE IS AN ACTIVITY WHICH ASKS YOU TO LIST THE KINDS OF
THINGS THAT COASTAL WETLAND OWNERS HAVE DONE TO ALTER THESE AREAS. TURN OFF THE RE-
CORDER WHILE YOU CARRY OUT THE ACTIVITY ON GUIDE SHEET #10.

WELL, I HAVE A FEELING THAT YOU HAVE PROBABLY GENERATED A RELATIVELY LONG LIST...
NOW LET'S SEE HOW SOME OF THE ACTIVITIES YOU LISTED HAVE ACTUALLY ALTERED AND POL-
LUTED ESTUARIES IN THE COASTAL ZONE. TURN TO GUIDE SHEET #12... THERE YOU HAVE A G.S. #12
LIST OF USES OF ESTUARIES AND THE TYPES OF ALTERATION AND POLLUTION THESE LAND USES
HAVE BROUGHT ABOUT. TURN OFF THE RECORDER WHILE YOU STUDY GUIDE SHEET #12.

SINCE 1969, SEVERAL PROGRAMS DEALING WITH TIDAL WETLANDS HAVE COME INTO BEING THAT COMPLEMENT THE TIDAL WETLANDS ACT.

THE COASTAL MANAGEMENT ACT, PASSED BY THE UNITED STATES CONGRESS IN 1972, TAKES NOTE OF THE IMPORTANCE AND FRAGILITY OF COASTAL ZONE AREAS AND THE MANY COMPETING USES IN THESE AREAS. THE ACT RECOGNIZES MANY OF THE INADEQUACIES IN COASTAL ZONE PLANNING AT THE STATE LEVEL. THROUGH PLANNING GRANTS, THE LEGISLATION ENCOURAGES THE STATES TO TAKE ADEQUATE STEPS TO PROTECT COASTAL LAND AND WATER RESOURCES. THE BASIC THRUST OF THE LEGISLATION IS TO ENCOURAGE COMPREHENSIVE PLANNING AND MANAGEMENT, AS OPPOSED TO EFFORTS DESIGNED ONLY TO COUNTER SPECIAL PROBLEMS SUCH AS WETLANDS PROTECTION.

PLANNING REQUIRES A SYSTEM OF IDENTIFICATION AND CLASSIFICATION OF GENERAL AREAS OF ENVIRONMENTAL CONCERN. SUCH AREAS ARE IDENTIFIED AS THOSE WHERE UNCONTROLLED DEVELOPMENT MIGHT LEAD TO SIGNIFICANT ADVERSE ENVIRONMENTAL IMPACT.

AT THE UNITED STATES SENATE HEARING ON THE COASTAL ZONE MANAGEMENT ACT THREE CAPABILITY DESIGNATIONS WERE STIPULATED FOR PLANNING PURPOSES. THESE THREE DESIGNATIONS ARE...LISTED AT THE BOTTOM OF GUIDE SHEET #12. G.S. #12

1. VITAL AREAS OF PRESERVATION AREAS: ECOSYSTEM ELEMENTS OF SUCH CRITICAL IMPORTANCE AND VALUE THAT THEY ARE TO BE PRESERVED INTACT AND PROTECTED FROM HARMFUL OUTISDE FORCES - ENCOMPASSED WITHIN AN AREA OF ENVIRONMENTAL CONCERN.
2. AREAS OF ENVIRONMENTAL CONCERN OR CONSERVATION AREAS: BROAD AREAS OF ENVIRONMENTAL SENSITIVITY, OFTEN CONTAINING ONE OR MORE VITAL AREAS, THE DEVELOPMENT OR USE OF WHICH MUST BE CAREFULLY CONTROLLED TO PROTECT THE ECOSYSTEM.
3. AREAS OF NORMAL CONCERN OR UTILIZATION AREAS: AREAS WHERE ONLY THE NORMAL LEVELS OF CAUTION ARE REQUIRED IN UTILIZATION AND IN DEVELOPMENT ACTIVITY.

IDENTIFYING WETLAND AREAS AND CATEGORIZING THEN FOR PLANNING PURPOSES IS JUST A BEGINNING. THERE ARE MANY AGENCIES WHICH HAVE JURISDICTIONAL POWERS IN THE COASTAL ZONE. GUIDE SHEET #13 SUMMARIZES THE STATE AGENCIES WHICH HAVE AN INVOLVEMENT IN THE COASTAL ZONE. TURN OFF THE RECORDER WHILE YOU STUDY GUIDE SHEET #13. G.S. #13

IN IMPLEMENTING THE COASTAL MANAGEMENT ACT, STATES MUST DETERMINE WHAT ROLE THEY WILL PLAY RELATIVE TO LOCAL GOVERNMENT. DETERMINATIONS MUST BE MADE AS TO WHERE THE INLAND BOUNDARIES DEFINING THE REGULATED COASTAL ZONE SHALL BE SET. IN ADDITION TO JURISDICTIONAL QUESTIONS, STATES WILL ALSO HAVE TO RESOLVE MANAGEMENT PROBLEMS SUCH AS ADEQUATE ASSESSMENT OF CHOICES, SOUND DECISIONS ON LAND USE PRIORITIES, PUBLIC PARTICIPATION, PUBLIC ACCESS TO BEACHES, MONITORING AND ENFORCEMENT. ONLY TIME

AND PERFORMANCE WILL TELL THE FATE OF THE COASTAL ZONE MANAGEMENT CONCEPT.

IN 1974, CONNECTICUT RECEIVED ITS FIRST COASTAL ZONE PLANNING GRANT. THE PROPOSAL STATES THAT THE OVERALL GOAL OF THE COASTAL ZONE MANAGEMENT PROGRAM IS PROTECTION, PRESERVATION AND RESTORATION, AS WELL AS DESIREABLE ECONOMIC UTILIZATION OF CONNECTICUT'S COASTAL RESOURCES. THESE ARE ADMIRABLE GOALS. AS THE PROGRAM IS IN ITS FORMATIVE STAGES, IT IS TOO EARLY TO REACH ANY CONCLUSIONS ABOUT ITS POTENTIAL SUCCESS. A STATEMENT OF OBJECTIVES FOR CONNECTICUT'S COASTAL ZONE PROGRAM ARE OUTLINED ON GUIDE SHEET #14. G.S.#14

A SERIES OF STATEMENTS ON THE PROBLEMS AND ISSUES INVOLVED IN THE CONNECTICUT COASTAL ZONE MANAGEMENT PROGRAM ARE PRESENTED ON GUIDE SHEET #15. STOP THE RECORDER AND STUDY GUIDE SHEETS #14 AND #15. G.S.#15

THE COASTAL ZONE OF THE ENTIRE LONG ISLAND SOUND AREA HAS BEEN THE FOCUS OF ANOTHER PLANNING PROGRAM FUNDED THROUGH THE NEW ENGLAND RIVER BASINS COMMISSION BETWEEN 1971 AND 1975. THE FINAL REPORT OF THE LONG ISLAND SOUND STUDY IS CONCERNED WITH MANY OF THE TOPICS OF THE LAND USE DECISION MAKING KIT. IT SUMMARIZES MANY OF THE PROBLEMS AND POSSIBLE SOLUTIONS OF THE COASTAL ZONE ON LONG ISLAND SOUND. TOPICS INCLUDED IN THE REPORT ARE WATER POLLUTION CONTROL MEASURES, DREDGING AND SOILS DISPOSAL, WATER SUPPLY, FISHING, WILDLIFE, LAND USE, RECREATION, WETLANDS, ENERGY FACILITIES SITING, NATURAL FORCES, HARBORS, POPULATION, ECONOMIC GROWTH, AS WELL AS A LONG LIST OF POSSIBLE SOLUTIONS. WHILE THE REPORT IS A DISCUSSION STIMULANT, IT DOES NOT SUGGEST PRIORITIES, PERFORMANCE STANDARDS OR SOURCES OF FUNDING FOR THE PROGRAM SUGGESTIONS. A COPY OF THE REPORT, PEOPLE AND THE SOUND IS INCLUDED IN THE KIT.

FOR COASTAL ZONE PLANNING TO BE EFFECTIVE, IT MUST BE COMPREHENSIVE AND INTEGRATED. PLANS MUST BE FOLLOWED BY SOUND MANAGEMENT AND ENFORCEMENT BY STATE AND LOCAL AGENCIES. EVEN THE FINEST PLANS WILL NOT BE SUCCESSFUL WITHOUT YOUR SUPPORT. THROUGH ACTIVE PARTICIPATION IN THE DECISION MAKING PROCESS, PLANS CAN BE ADJUSTED TO MEET YOUR DESIRES AND NEEDS AS WELL AS THOSE OF YOUR COMMUNITY. PLANS WITH WIDE SPREAD SUPPORT STAND A MUCH BETTER CHANCE OF BEING EFFECTIVELY IMPLEMENTED THAN PLANS WHICH ARE MANDATED BY AN AGENCY OR TOWN COMMISSION.

TO COMPLETE THIS UNIT, REVIEW SECTIONS OF PEOPLE AND THE SOUND THAT ARE OF PARTICULAR INTEREST TO YOU. PAY PARTICULARLY CLOSE ATTENTION TO PAGES 20 TO 24 OF THE REPORT. ON THESE PAGES YOU WILL FIND SPECIFIC RECOMMENDATIONS FOR MANAGING THE COASTAL ZONE. IT MIGHT BE INTERESTING TO COMPARE THE RECOMMENDATIONS FOR MANAGEMENT OF THE COASTAL ZONE IN PEOPLE AND THE SOUND WITH THE MANAGEMENT PRINCIPLES ON GUIDE SHEET #16 DEVELOPED BY JOHN CLARK OF THE CONSERVATION FOUNDATION. G.S.#16

THIS ACTIVITY CLOSES THE UNIT ON COASTAL WETLANDS. WE HOPE THAT YOU WILL FIND THE INFORMATION IN THE UNIT TO BE OF VALUE TO YOU AND YOUR COMMUNITY.

SYNTHESIS SCRIPT

Voice 1: Planning and design are not magical processes. A planner does not mix all of a town's ingredients in a caldron, stir them around and pour out a well organized, functioning community. It just doesn't work that way. The only aspect of that description that is accurate is that the final product is a combination of all the parts of a town. In the other units, we have looked closely at these discrete parts. We looked at the people, the primary uses of the land, and population studies. We looked closely at the natural systems: geosystems, hydrosystems, uplands, and wetlands. We discussed characteristics and their sensitivities to change and development. Then, we looked at man-made systems that are placed upon the land and we talked about how we can begin to evaluate the impact of these systems.

Now it is time to take these parts, the ingredients of the "land use planning process" and develop a logical method for making informed land use decisions. Each unit in the land use decision making kit has approached the study of the components with logic, reason, and a critical eye. This approach should be continued in the final integration of information which we call the synthesis process.

Rob Pressman, a professional landscape architect, has agreed to join us for the synthesis unit. His point of view on the problems and prospects of planning a sound environment for people and their institutions is based upon practical experience.

As Rob Pressman discusses the planning process, you should be aware of the fact that he is discussing a generalized approach. The concepts and procedures are generally accepted. However, local and state laws do have a bearing on the process and it may be necessary for you to modify the approach to meet the requirements of your community.

We appreciate Rob Pressman's willingness to help pull all of the pieces of the land use decision making process together in the synthesis unit. We will now turn the balance of the unit over to him...

Thank you. It is a pleasure to be with you.

Voice 2: Today, the environmental consciousness of people is growing. As a result, planning has to be responsive to a broad range of issues. The days of the design scratched out on the back of an envelope are long gone. Planning and design is no longer a one shot deal. How much freedom can, or should a designer have when he is responsible to thousands of people? How much freedom can the designer exercise when he must consider the values of diverse public interest groups each pursuing their own needs? There are the corporate developers who seek maximum profits. There are the local town planning boards who want to maintain balanced growth. There are the environmental protection agencies and conservation groups interested in maintaining environmenal quality, and other local citizen groups who wish to maintain the status quo! The planner and designer are confronted with these conflicting interests. They must be able to avoid bias and attempt to promote the common good. To do this they are obligated to perform a systematic, thorough analysis of available information. This approach closely approximates an objective decision-making process. There have been a number of synthesizing methods developed over the recent years, many involving computers. The computer, as a tool, has tremendous possibilities because of its ability to store large quantities of data and perform a multitude of operations in a very short period of time. The wide scale application of computer technology to land use decision making is far in the future and will not help those towns that presently are in need of planning studies and cannot afford the comforts of a computer. So we will begin to discuss a synthesis technique that can adequately be done by hand as well as by the computer.

Performing any synthesis operation requires extensive note-taking and recording. As we discussed in the cultural unit, people interested in planning should become comfortable with a pen or pencil and should lose their self-consciousness about their ability to draw. You do not have to be an artist to record the kinds of information that we are dealing with. In the cultural unit, we discussed many recording techniques. If you are not familiar with these techniques return to those guide sheets in the Cultural Unit which discuss recording techniques.

There are two alternatives in this unit: You may follow along as we outline the synthesis process or you may use all the data you have accumulated about your town or a site in your town in the synthesis process. This second alternative will take longer but can be more rewarding. There is a greater likelihood that you will understand the synthesis process if you participate in it. Now let's begin with the basic synthesis concepts.

Turn to Guide Sheet #2. Here on Guide Sheet #2, you can see how the synthesis process functions in land use decision making. Essentially, the synthesis process integrates the needs of a population, the requirements of natural systems, and the nature of the land. (Pause) G.S. #2

If "land use planning" is the planning or locating of uses on the land, then our primary concerns are with the land and the land uses. With the land we are interested in preserving and respecting its ecological integrity. In the natural systems units we learned of the land's vulnerabilities to disruption by development. Planning methodologies in the past that have not considered these vulnerabilites have often been responsible for the erosion of topsoil, mudslides, contaminated water supplies, dying lakes and streams, and flooding. Here we are discussing a methodology that avoids these severe environmental impacts. The approach to the land then, is to consider what "should not be". In other words, where are the areas that should not be developed due to their vulnerability to environmental disruption. Areas of high potential environmental impact or disruption are unbuildable areas. "Buildability" is another term used to describe this concept of land vulnerability. It means just what it says: buildability refers to the ability to build in a certain place.

When we talk about the "land uses" and their location we take the opposite viewpoint and consider "what should be". Land uses have intrinsic needs for survival, they each have certain requirements on which they thrive. In other words, land uses should be in certain places because of their specific needs. We use the term "attractiveness" to describe these supportive characteristics of a land use.

Our synthesis process is based upon these two concepts: environmental impact which we call buildability and land use attractiveness. If you were able, in your town, to eliminate from consideration for future development all of the areas that were unbuildable due to the high potential of environmental impact, and to pick out , from the remaining land, those areas where different land uses would be most"attractive", you would have the makings of a viable, ecologically sound development plan.

The graphic technique we use to synthesize or integrate information on buildability and attractiveness is called an "overlay" technique. Refer to guide sheet #3 as we discuss how this method works. G.S. #3

The overlay technique allows us to examine the inter relationships that exist among various kinds of data categories. This technique for exploring the interrelationships of various pieces of data for a given land area has become an important tool for planning projects at all levels.

The process is relatively simple. Information on a single specific aspect of the land is transferred from a map to a clear sheet of acetate. In guide sheet #3, we might assume data type #1 to be slope... on transparency #1 we might use a color or symbol to indicate all areas exceeding a slope of 15% for example. Data type #2 could be information on wetland soil types... The information is transferred from a soils map to the acetate, by outlining the wetland soils areas and marking them with special symbols or a special color. The same process is carried out for data type #3 which may, for example, designate areas with depth to bedrock of less than 3 feet... Now, if the data on each separate data factor has been drawn on a separate sheet of acetate and they are all at the same scale, we can overlay the acetates.. and study the interactions.

On guide sheet #3, we see that it is possible to combine information on slope and wetland soils, by overlapping acetates #1 and #2... likewise, we can combine information on wetland soils and depth to bedrock by overlapping acetates #2 and #3... if we are interested in combining information on all three data types, we can overlay transparencies #1,2, and 3.

Overlaying the transparencies on top of one another enables us to "look through" the data. We can begin to pick out where there are overlaps and conflicts.

In the diagram on guide sheet #3 we used different symbols for different data categories. Using different colors for different data categories will achieve the same goal. Because each piece of information is recorded on a separate sheet of acetate and is isolated from all others, any two or more categories can be overlayed and examined. The flexibility of the method is consistent with the underlying principle of inter-relatedness of the environment and its parts, with man-made systems.

..Ultimately, we plan to overlay an environmental impact map with a land use attractiveness map to yield a "land use allocation" map. The land use allocation map will make recommendations for future land use distribution. But first we must generate an environmental impact map and a land use atractiveness map.

Let's begin with the environmental impact composite map. This map will indicate those areas that are highly vulnerable to development. We must pick out those development aspects that might have an impact on the land, determine what those impacts might be and what environmental conditions will contribute to or are most susceptible to, destruction. For example, a building requires a foundation of some sort to support it. There are certain physical requirements for foundations which cannot be met in some areas, such as wetlands, without extensive modification of the land. To build in a wetland would require a fill operation which would destroy the wetland. Therefore we can say that a building would have a severe impact on a wetland areas. Almost all wetlands can be recorded as unsuitable areas for building. We will proceed with this type of evaluation for many buildability issues.

Septic tanks and leaching fields are common buildability considerations. These waste disposal techniques are utilized in towns or areas where municipal sewage collection treatment systems are not provided. Septic systems are on-site systems, consisting of an underground septic tank that collects sewage and finger-like pipes, called the leaching field, that disperse the sewage effluent throughout the soil. On guide sheet #5, you will find a sketch of a septic system. The principle behind the system is quite simple. As effluent from the septic system moves through the soil, it will be acted on by bacteria and micro-organisms and will eventually become harmless. The efficiency of this method is dependent upon a great many factors which are outlined in detail in the geosystems unit. The potential danger involved is that under improper conditions, untreated effluent can reach the water table and contaminate the ground water. Another possible impact of an improperly designed or installed on-site septic system is the emergence of the raw effluent from the soil. G.S. #5

The primary factors that influence the functioning of a septic system is the absorption capacity of the soil and depth to bedrock or hardpan. The rate of infiltration of sewage effluent into the soil must be adequate - the standard rule of thumb indicates a percolation rate of greater than 1" per hour, in most cases, will preclude the possibility of unsanitary surface conditions. Percolation tests give us a measure of the permeability of the soil and allow us to determine the suitability of a particular soil series for on-site sewage treatment. On guide sheet #6, there is a summary of the procedure for performing a percolation test. If you did not complete Geosystem A-T Unit, stop the recorder and read guide sheet #6. (Pause) Soils with suitable percolation rates for septic systems can be found by using the Soil Conservation Service Soil Survey Map and the Percolation Rate Key for the map. G.S. #6

The reading of soil maps and keys is covered in the Geosystems Unit. Determinations of where septic systems can be utilized for on-site sewage treatment can not be based upon a single factor analysis. Several factors must be considered.. a septic tank suitability review can be found at the top of guide sheet #7. A series of overlays can be developed for each factor and the overlay techniques can be used in determining which land areas are appropriate or inappropriate for septic systems. G.S. #7

Ground-water level, during the wettest season, should be at least 4 feet below the bottom of subsurface-tile trench. This is true for hardpan soil and bedrock as well. Therefore there must be a minimum of 4 feet of well-drained soil below the tile field to ensure adequate treatment.

Slopes in excess of 15% are unsuitable for tile fields and seepage beds. Leaching fields are not only difficult and costly to lay out and construct in areas with greater than 15% slope, but lateral seepage is likely to occur resulting in the suracing of sewage effleuent down-slope.

Another unsuitable site for a septic system is land within 50 feet of a stream or other water body. The fifty foot buffer zone prevents possible contamination of the body of water with sewage effluent. Septic systems should never be installed on a flood plain.

Now that we have reviewed the requirements for septic tank suitability we can begin to produce a septic system suitability map. On this map we will outline all of the areas in our town or site that fall into any one of the unsuitable categories that we have described.

On guide sheet #8 there is a graphic representation of a map of unsuitable areas for septic systems. If you are working with your data for your town, place an acetate sheet over the soils map for your town. Using the keys in the geosystems unit color each of the soil phases that are unsuitable based on percolation rate, depth to bedrock, depth to watertable and slope. Turn the recorder off while you make your single factor transparencies. The composite of the finished acetates will indicate areas which are unsuitable for septic systems. (Pause) G.S. #8

A second buildability issue is "erosion susceptibility" or the potential of an area to erode when it is developed. Another term used to describe erosion potential is "erodibility".

Erosion was discussed in the geosystems unit in detail. But let us refresh our memory.

When rain falls, or water from any source runs downhill on bare soil, it moves soil particles, organic matter, and soluble nutrients. This process is called erosion. To avoid erosion, the soil must be protected from moving water. Dense vegetative cover will intercept rain and slow water runoff, thereby providing the best natural deterrent to erosion.

The possible impacts of erosion are numerous. Bottom-land farmers are concerned with erosion on the uplands because soil may wash down and cover their crops. Infertile materials may be deposited on their good land and impair the drainage of their fields.

Silt from erosion often chokes streams and fills reservoirs; it pollutes water supplies and depletes storage; it destroys wildlife and recreational areas. The deposition of soil where it is not wanted may be as damaging as its removal from its original position.

New development is a major contributor to soil erosion. Usually during construction the only natural defense against erosion - vegetation - is stripped away. Each year more than 2 million acres of land in the United States are converted from agricultural use to urban use. Studies show that rates of erosion on land going into use for highways, houses, and commerce is about 10 times greater than the erosion rate of land in cultivated row crops; 200 times greater than on land in pasture; and 2,000 times greater than on land in timber.

Why is there so much erosion associated with development activities? Well, first of all, large earth moving equipment has made the reshaping of the land easier and faster and has brought steeper and rougher land into use. These steeper lands have high erodibility and as soon as vegetation is cleared, severe erosion occurs with the first rain. The trend toward large subdivisions and developments has left cleared and graded areas exposed to erosion for a long time. To facilitate the movement of large earth movers and to cut costs, developers frequently have all existing vegetation stripped away during construction. Eventually seedlings and sparse ground cover are planted, but initially, they provide little if any protection against erosion. Even after construction, rapid runoff from impervious surfaces - sidewalks, parking lots, courtyards, and compacted soil - causes extensive erosion damage in erodible areas.

There are measures that can be taken during construction that reduce erosion potential. These are outlined on guide sheet #13 of the geosystems unit and in the Soil Conservation Service pamphlet entitled Soil Erosion. On guide sheet #9, you will find a list of the natural factors that are directly related to erosion.

G.S. #9

The primary natural factors are soil type, vegetative cover and slope. There are certain soils which are more susceptible to erosion. The Soil Conservation Service (SCS) has classified soils as to their erosion potential in their description of the engineering uses of soils in the published soil survey. Soils with severe erodibility can be first recorded on your erosion map. Transfer this information to an acetate sheet overlayed on your town soils map. If you are not working with your town data, there is a graphic representation of an erosion map on guide sheet #10. (Pause)

G.S. #10

Slope is a consideration usually included in the S.C.S. Classifications but to emphasize the point, let us repeat that steep slopes have greater erodibility. Areas with extreme slope conditions, greater than 25% can be recorded on your map. Finally, vegetation as we have noted is a front-line defense against erosion. An area with dense, well-developed vegetative cover impedes run-off and holds soil in place. Slopes where vegetation hasn't taken hold or any area that has recently been disturbed, such as logging areas, are highly susceptible to erosion and can be recorded on the map. (Pause)

Foundation suitability is still another obvious buildability issue. Buildings need foundations and foundations need suitable conditions. We must admit that building technology is sophisticated enough to be able to meet the demands of any site or circumstance. Costs incurred in overcoming unusual conditions tend to be technologies limiting factor. My recommendation then is to exclude those areas where unreasonable costs would be incurred in construction as well as areas sensitive to development activities. Inappropriate foundation conditions can result in instability and are associated with the collapse of buildings, cracking walls, or sliding or settling of the entire site. Also unsanitary conditions of wet basements can result from unsuitable conditions.

Criteria used to determine suitability for building foundations includes slope, soil characteristics, depth to bedrock and water table. These are outlined on guide sheet #11, a review of

G.S. #11

foundation suitability.

Concerning slope conditions, we encounter moderate foundation limitations at 15% and severe limitations on slopes greater than 25%. This includes economic as well as structural considerations. Slope and soils are inter-related. The bearing capacity and consolidation characteristics of the soil must be considered to avoid areas with collapse or sliding potential. Depth to water table is particularly significant in considering foundations where basements are involved. To eliminate potential flooding, special design or site preparation, the water table should be of a depth greater than 10 feet, in construction involving basements.

Depth to bedrock is essentially an issue that affects construction costs. Shallow bedrock involves blasting and excavation work which is costly and time consuming. If the bedrock lies at a depth greater than 10 feet, construction problems will be avoided for most types of foundations.

Refer now to guide sheet #12 for a graphic map of foundation suitability. If you are working with your town data, outline foundation suitability areas on a clear acetate sheet placed over your town map. (Pause) G.S. #12

Now let us move on to study the issue of flooding. Prior to man there were floods but limited flood problems. There was no one around to be bothered by floods. There was no damage to property or to human life. Flood problems began with the construction of the first structure in a flood-plain area at a level below flood heights. Other developments followed. As agricultural, residential, commercial and industrial use of the flood plains grew, the personal and economic losses from floods multiplied as well. Man has tried with large-scale works, such as reservoirs, flood walls and levees, to prevent or reduce the natural extent of flood inundation but this effort has only been partially effective. Each year, flood losses exceed $1 billion, not including the loss of life.

Flood control is a natural function served by flood plains, stream channels, wetlands and natural retention basins. Please refer to the Inland Wetlands and Hydrosystems A-T units to gain a greater understanding and appreciation of these natural systems. (Pause)

With a better understanding of the functions of these systems, we should be able to recognize why man should not tamper with them and should exclude them from development. Increasingly, planners are accepting the 50 year flood plain as that area from which all development should be excluded, except for functions which are unharmed by flooding or for uses that are inseparable from flood plains. Guide sheet #13 has a review of flood plain construction considerations. G.S. #13
Uses that are unharmed by flooding include agriculture, forestry and open space. Land uses that are inseparable from flood plains are marinas, water-related industry and water using industry.

In land use planning considerations, we can see that flood plains and wetlands are generally unsuitable for development. The impacts on the environment, and the impacts on man as a result of development in these areas are severe enough to warrant designating these areas as unbuildable zones on our buildability maps. Guide sheet #14 has a graphic representation of a map of flood potential. Based on your town data, create an acetate overlay indicating areas of flood potential.

G.S. #1

Ground water is our next environmental impact issue. Here we are concerned with two issues... water quality and ground water recharge. Hydrosystems are fully examined in the Hydrosystems unit, but we will review the major concepts and discuss how they relate to urbanization.

As rain falls and is absorbed into the soil, it replaces water that has evaporated or it is used by plants. After the needs of the plants and soil are satisfied, the excess water reaches a zone of saturation where all of the openings in the rock and soil are filled with water. This zone is called "ground water". Ground water flows, but very slowly. Thus, groundwater is able to be tapped by wells for drinking water, or emerge as springs, or seep into a stream miles from its point of entry into the ground. In most streams, the water that flows during dry spells is largely ground water. These last points are important in terms of human impacts. If ground water becomes polluted, then man's drinking water is contaminated and surrounding streams will be polluted as well.

The question then is how does ground water become polluted? One way is through the improper siting and/or installation of a septic/leaching system. A second way in which ground water becomes polluted involves aquifer recharge areas that replenish the supply of groundwater in aquifers. An aquifer is a large water bearing layer of rock, gravel, or sand. An aquifer recharge area is, as the name implies, the point of interchange between surface water and aquifers. It is the movement of ground water to surface water that contributes water to rivers and streams in periods of low flow. Obviously, these points of interchange are also locations where a polluted river may contaminate the pure water resources in the aquifers. These recharge areas are critical for the management and protection of ground water. Many areas without municipal water supply rely on ground water to obtain water in their wells. On guide sheet #15, you will find a list of factors which might have severe impact on ground water quality. - depth to water table and aquifer recharge areas. Areas with shallow water table should be recorded as unsuitable for septic tank systems. These areas should already be marked on the septic system suitability map. Aquifer recharge areas should also be recorded as unsuitable for many forms of development. Land uses such as agriculture, forestry, recreation and low density development pose no danger while industry and urbanization in general do. Refer now to guide sheet #16 for a stylized map of areas that, if developed, will potentially lead to contamination of ground water. (Pause)

G.S. #1

G.S. #1

We now come to two issues which are somewhat different than the previous ones - vegetation and wildlife. Both are environmental features that are very sensitive to development yet have little impact on the land uses themselves in the way that flooding and erosion do. Vegetation and wildlife can be destroyed, much to the detriment of environmental quality. But they can't strike back. On the other hand, a flood plain that has been extensively developed will have its revenge when a 50 year flood demolishes everything in its path.

Vegetation plays a good many roles in our environment. Besides providing infinite beauty in the landscape, it serves as an erosion deterent, wildlife habitat, oxygen producer and air purifier, shade-maker and playground. Yet, as urbanization approaches, it is the first thing to go. Up until this time it was considered economically viable to clear the land of any existing vegetation, save nothing, and replant after construction. Finally, today, it is becoming increasingly clear to developers that trees and shrubs have tremendous economic value and are worth saving. This value is apparent in the types of development that people prefer to live in these days.* People are demanding that their living and working environments abound with vegetation. Developers must respond to this demand. Ultimately they find that their profits are greater when vegetation is protected because people are willing to pay for the lush surroundings. A review of vegetation considerations is presented on guide sheet #17. G.S. #17

So with the importance of vegetation increasing, we might choose to make a map of vegetation as graphically illustrated on the left hand side of guide sheet #19. (Pause) Vegeta- G.S. #19 tion that is significant or special in some way, should be preserved. These areas should be recorded on a map and be considered as zones that are unsuitable for most development, recreation probably being the only exception.

Wildlife plays an even less obvious role in environmental quality. But, just as our interest in and concerns for vegetation are growing, our wildlife consciousness is expanding as well. Talk of endangered species has become quite common and the numbers of bird watchers increases every year.

Wildlife habitats differ, obviously, for each different type of animal. Streams and lakes, we know, house various fish species. Ducks, beaver, muskrats and otter live along streams as well as in other wet areas. Deer, skunks, woodchucks, chipmunks, squirrels, fox, rabbits, grouse and many other animals can be found in uplands and open space areas. Birds often prefer edge conditions - along waterways, roads or forest. It is difficult to make generalizations about specific habitat preferences. Each community will have different wildlife with different habitats. Guide sheet #18 reviews wildlife considerations. You may already be familiar with wild- G.S. #18 life habitats in your town. If not, begin to make inquiries about important wildlife areas or go out and discover what's out there for yourself. Once you find out, you can map out important habitats as is illustrated on the right hand side of guide sheet #19. Once you have located and G.S. #19 marked these areas on your map, take action to prevent them from being destroyed by future development.

Now that we have discussed and generated separate maps concerning development suitability, we can "synthesize" our information and derive a composite map that will include all of the data that we have previously recorded. Each "single factor map" contains areas which we have determined to be unsuitable for development. Since we have only recorded severe conditions, our composite map will show us all areas in our town which should not be considered at all for development. Each category must be considered as having equal importance in the decision making process. The overlays we have developed are placed on top of one another. Make sure that they all line up properly on the base map. Now, take a clean piece of acetate, place it on top of the stack, and trace off the sum total of all the areas marked on the single-factor maps. This final map is your composite building suitability-environmental impact map. When placed on the base map of your town or site, it will delineate those areas that are unbuildable, for one reason or another. Refer to the guide sheet #20 for an illustration of the preparation of a buildability composite. G.S. #20

We chose to only record severe conditions for illustrative purposes. Actual planning studies would not only record severe limitations, but would break down the data into other categories and record them as well. For example, we said that septic tank systems were unsuitable in areas with a percolation rate of less than 1" per hour; with less than 4 feet of soil beneath the tile trench; and on slopes in excess of 15%. We could approach the issue of septic systems from the other end and describe those areas where the system would be most suitable. And then, of course, there are characteristics that describe areas where it is moderately suitable. These categories would be included in a professional study. Each single-factor map would have three colors or symbols on it, representing the suitable, moderatley suitable, and unsuitable zones.

When it comes time to do the composite map and all of the maps are overlayed, it becomes very difficult to interpret the results if varying levels of suitability are included. This is why we dealt only with severe limitations condition. Now you can probably better understand why the computer is becoming a very valuable tool in land use planning. It has the capacity to make the subtle distinctions that our eyes have difficulty making. On guide sheet #21, we have reproduced a copy of a septic tank suitability map produced by a computer. G.S. #21

Instead of drawing maps by hand, the computer can analyze data in its memory and print out single factor or composite suitability maps. Stop the recorder while you study the computer generated maps on guide sheets #21 and #22. G. S # 22

Presently, there is federal legislation being drafted to create a National Land Use Bank that would store environmental information for all parts of the United States in one computer center. As development occurred anywhere in the country, the data would be punched in and the bank would be continuously updated. The accumulation of data for this sophisticated system will take an extended period of time. However, once it is completed, environmental impact statements on any parcel of land in the country could be assembled rather quickly.

Voice #1: Thank you, Mr. Pressman for taking the time to review the buildability issues of the synthesis process. We look forward to joining you in Part II of the synthesis unit which deals with the issue of attractiveness. Before we continue with Mr. Pressman, I would like to review the preparation of the final buildability composite. We have prepared three overlays from which you can construct a buildability composite for a sample site. Turn off the recorder while you G. S. #23 work on the activity on guide sheet #23.

Now that you are thoroughly versed in the principles of the synthesis process, it is important to move from theory and principle to a practical analysis that can be performed with this technique. In the final part of this unit, we will concern ourselves with two applications of the synthesis process - evaluation of a site plan for a subdivision or planned unit development and the siting of a sanitary landfill.

Let's begin with the evaluation of the site plan for a subdivision or planned unit development. The Natural Resources Center of the Department of Environmental Protection has developed an analysis for this situation by outlining a comprehensive set of questions that aid us in evaluating natural resource considerations. These questions are listed in guide sheet #28. (Pause) G. S. #28 The questions are a detailed form of the buildability analysis that we completed with Mr. Pressman. Stop the recorder while you read through the questions. (Pause)

Welcome back! I am sure by now you are thinking there are a lot of questions without many answers. On guide sheet #29, the questions about subdivisions are expanded into a matrix that G. S. #29 includes the questions, the conditions to evaluate and the resource information needed for evaluation. On the right hand side of the matrix, there are columns which contain criteria for evaluation. These criteria are broken down into three categories: normal considerations, conflict - requires special design or site preparation, and critical conflict. In a critical conflict situation, a problem may be prohibitive even with special design or site preparation. In these columns, the reason for the evaluation is provided. The caption at the top of the right hand side, states that the criteria for evaluation require data based on maps, reports, or on-site inspection.

In order to locate the information on the appropriate map, the Natural Resource Center has G. S. #30 prepared two other matrices. These may be found on guide sheets #30 and #31 The matrices G. S. #31 cross match standard types of maps with types of information needed for the evaluation.

Probably at this point you are overwhelmed by matrices and questions...this is not unusual. Slowly start on the first page of guide sheet #29. Work your way through one question at a time. Each time you need a piece of information proceed to the resource information chart to locate which map contains the needed information. Continue in the same manner through each question on guide sheet #29. When you are finished you will have a solid knowledge of the natural resource consideration in evaluating a subdivision. Turn the tape recorder off while you work. (Pause)

Now that you have had some experience in natural resource considerations for subdivisions, it is time for us to turn out attention to siting a sanitary landfill. Locate the pamplhet entitled Use of Natural Resource Data in Land and Water Planning in your land use decision making kit. This report was written by David Hill and Hugo Thomas, two respected planners. In the pamphlet, Hill and Thomas carefully outline the synthesis/buildability process for locating a landfill. They follow the same process that we have - a description of basic resource data, compilation of available data, a resource interpretation system and finally the collating of the single factor maps into a composite. Stop the tape recorder while you read the bulletin. Turn the tape recorder on again when you are finished.

It is important to ask one final question: Who will assemble and analyze the resource data to present the options to citizen decision makers? It is a difficult question. A partial answer can be gained from the pamphlet The Environmental Review Team - Evaluation of Land Use Proposals. This pamphlet is in your land use decision making kit. As you can see the synthesis process includes many considerations. By careful work and planning we can make provision for an expanding population and economy, while maintaining the integrity of the environment.

VOICE 1: THE ISSUE OF BUILDABILITY, THE ABILITY TO BUILD IN A PLACE WITHOUT CAUSING SEVERE ENVIRONMENTAL IMPACT, HAS BEEN DEALT WITH IS PART ONE OF THIS UNIT. HERE, IN PART TWO, WE WILL TAK A CLOSE LOOK AT LAND USE ATTRACTIVENESS. LAND USE ATTRACTIVENESS DESCRIBES WHERE A LAND USE SHOULD BE, BASED UPON ACCESS, PROXIMITY REQUIREMENTS AND SITE CHARACTERISTICS. AT THE END OF THIS UNIT WE WILL FIND OUT HOW INFORMATION ON BUILDABILITY AND LAND USE ATTRACTIVENESS CAN BE INTEGRATED TO PRODUCE A LAND USE ALLOCATION MAP. ROB PRESSMAN, A PROFESSIONAL LANDSCAPE ARCHITECT, WILL JOIN US AS THE NARRATOR FOR THIS UNIT.

VOICE 2: WE WILL NOW MOVE ON TO THE SECOND IMPORTANT STAGE OF THE SYNTHESIS PROCESS. AS YOU RECALL, THE TERM WE USED TO DESCRIBE THE INTRINSIC REQUIREMENTS OF VARIOUS LAND USES WAS, "LAND USE ATTRACTIVNESS." NOW THAT WE HAVE FOUND, THROUGH THE BUILDABILITY ANALYSIS, WHERE DEVELOPMENT SHOULD NOT BE, WE WILL BEGIN TO DISCOVER WHERE SPECIFIC LAND USES SHOULD BE LOCATED. WE CAN DO THIS BY DISCUSSING THE LAND USES, EXPLORING THEIR CHARACTERISTICS AND NEEDS, AND THEN FINDING ALL OF THE AREAS WITHIN OUR SITE THAT SATISFY THOSE REQUIREMENTS. THE INFORMATION IN THIS SECTION OF THE SYNTHESIS UNIT WILL BE RECORDED JUST AS IT WAS IN THE BUILDABILITY/IMPACT STUDY - DATA FOR EACH CATEGORY WILL BE RECORDED ON A SEPARATE ACETATE OVERLAY SHEET. ULTIMATELY, WE WILL CONSTRUCT A COMPOSITE OVERLAY, AND RESOLVE THE RESULTING CONFLICTS. THAT WILL TAKE US TO THE FINAL SYNTHESIS STEP, WHICH WILL BE TO COMBINE THE BUILDABILITY COMPOSITE WITH THE ATTRACTIVENESS COMPOSITE, YIELDING A FINAL MAP OF LAND USE ALLOCATION. AT THAT POINT, THE ECOLOGICAL PLANNING PROCESS WILL BE COMPLETE.

THE LAND USE CATEGORIES THAT WE WILL CONSIDER ARE: SINGLE AND MULTI-FAMILY HOUSING; COMMERCIAL, INDUSTRIAL AND INSTITUTIONAL DEVELOPMENT: UTILITIES; AND CONSERVATION. ATTRACTIVENESS DATA WILL BE ACCUMULATED FOR EACH OF THESE LAND USE CATEGORIES.

THERE ARE 3 PRIMARY QUESTIONS THAT WE CAN ASK OF EACH LAND USE TO GIVE US INSIGHT INTO ITS LOCATIONAL CRITERIA; THE FIRST QUESTION IS "WHAT ARE THE ACCESS REQUIREMENTS OF THIS LAND USE? WHAT TYPE AND QUALITY OF ROAD ACCESS DOES THE POTENTIAL LAND USE REQUIRE? SECONDLY, WHAT ARE ITS PROXIMITY REQUIREMENTS?

WHAT ARE THE NEEDS OF THE POTENTIAL LAND USE WITH RESPECT TO PROXIMITY TO, OR PROTECTION AND SEPARATION FROM VARIOUS OTHER LAND USES? AND THE THIRD QUESTION IS, WHAT KIND OF SITE CHARACTERISTICS WOULD BE APPROPRIATE FOR THIS LAND USE? WHAT TYPE OF SITE - WATERFRONT OR INLAND, FLAT OR UNDULATING, OPEN OR FORESTED - DOES THE POTENTIAL USE REQUIRE? THERE ARE OTHER QUESTIONS WHICH WILL BE ASKED OF SPECIFIC LAND USES, BUT THESE THREE ARE IMPORTANT QUESTIONS THAT CAN BE ASKED OF ALL OF THE USES BEING CONSIDERED.

WE WILL BEGIN OUR STUDY OF ATTRACTIVENESS WITH SINGLE-FAMILY HOUSING. SINGLE-FAMILY HOUSING IS JUST WHAT IT'S NAME IMPLIES - A HOUSE THAT SERVES AS A DWELLING FOR ONLY ONE FAMILY, AND IS GENERALLY INHABITED THE YEAR AROUND. THERE IS SEASONAL SINGLE-FAMILY HOUSING, CALLED "SECOND HOMES" WHICH HAVE VERY DIFFERENT ATTRACTIVNESS CHARACTERISTICS THAN PERMANENT HOUSING.

SINGLE-FAMILY HOUSING CAN BE CONSTRUCTED AT VARYING DENSITIES AND IN DIFFERENT CONFIGURATIONS. MOST NEW HOUSING DEVELOPMENTS IN SUBURBAN AND RURAL AREAS ARE INTRODUCED IN ONE OF TWO FORMS. FIRST, THERE IS THE CONVENTIONAL SUBDIVISION LAYOUT OFTEN ASSOCIATED WITH URBAN SPRAWL, AND SECONDLY THERE IS THE MORE RECENT ADOPTION OF AN OLD CONCEPT WHICH IS CALLED "CLUSTERING". TURN TO GUIDESHEET # 2 AS WE DISCUSS THEIR DIFFERENCES. (PAUSE)

G. S. # 2.

THE HOUSES IN EITHER DESIGN PLAN REQUIRE THE SAME BASIC SUPPORTIVE ELEMENTS BUT THEIR NEEDS ARE SATISFIED IN DIFFERENT WAYS. FOR EXAMPLE, THEY BOTH NEED YEAR - ROUND ACCESS BY ROAD; THEY BOTH NEED WATER AND SEWAGE FACILITIES; AND THEY BOTH NEED WELL-DRAINED SOILS FOR FOUNDATIONS. THERE HAS BEEN CONSIDERABLE STUDY AND RESEARCH COMPARING THESE TWO HOUSING OPTIONS AND THEIR FINDINGS FAVOR THE CLUSTER HOUSING CONFIGURATION. THE DATA ON GUIDE SHEET # 3 SUPPORTS THESE FINDINGS. IF YOU NEED MORE TIME TO STUDY GUIDE SHEETS # 2 AND 3, TURN OFF THE RECORDER.

G. S. # 2

G. S. # 3

"CLUSTER" IS COMMONLY DEFINED AS THE REDUCTION IN SIZE OF THE INDIVIDUAL HOUSE LOTS IN A SUBDIVISION, AND THE COMBINING OF THE CONSERVED LAND INTO SHARED OPEN SPACE FOR AESTHETIC AFFECT, ENVIRONMENTAL PRESERVATION, AND RECREATION. THE IDEA OF CLUSTERING HOMES TOGETHER AND USING THE SURROUNDING SPACE AS COMMON GREENS AND SQUARES IS CENTURIES OLD: IT IS THE PRINCIPLE OF BOTH THE MEDEVIL VILLAGE AND EARLY NEW ENGLAND TOWNS. HISTORICALLY, AMERICANS LIVED QUITE CLOSE TOGETHER IN TOWNS AND CITIES. THEN, IN THE 1930'S, THE AMERICAN DREAM OF A COUNTRY HOME WAS TRANSLATED INTO THE GROWTH OF SUBURBIA. THERE WERE SEVERAL ATTEMPTS IN THE LATE 20'S AND IN THE 30'S BY PLANNERS TO SHOW THAT GRIDIRON DEVELOPMENT WAS NOT THE SOLE PATTERN FOR DEVELOPMENT. RADBURN, N. J., THE GREENBELT TOWNS OF THE NEW DEAL AND BALDWIN HILLS IN CALIF. WERE ALL QUITE SUCCESSFUL HOUSING DEVELOPMENTS AND ARE THE PREDECESSORS OF PRESENT CLUSTERING ATTEMPTS. UNFORTUNATELY, SUBURBAN SPRAWL HAS CONTINUED AND HAS BECOME THE BLIGHT

THAT WE ALL KNOW WELL.

THE DIFFERENCES BETWEEN CLUSTER AND CONVENTIONAL HOUSING ARE EASY TO ENUMERATE. A DEVELOPER OF A GRIDIRON SUBDIVISION IS ALMOST ALWAYS FORCED TO UTILIZE THE ENTIRETY OF HIS PROPERTY FOR HOUSE LOTS, STREETS AND RIGHTS-OF-WAY.

IN AREAS WHERE LAND IS CHARACTERIZED BY STEEP SLOPES, WETLAND, OR UNIQUE SCENIC OR ENVIRONMENTAL AMENITIES, PREPARING A GRIDIRON SITE PLAN CREATES SOME DIFFICULT PROBLEMS. FREQUENTLY, DEVELOPERS ARE FORCED TO LOCATE SOME LOTS, HOUSES AND STREETS IN LESS-THAN-IDEAL PLACES.

CLUSTER PLANNING ON THE OTHER HAND, OFFERS A REASONABLE, PRACTICAL SOLUTION TO THESE PROBLEMS. CLUSTER DESIGN ENABLES DEVELOPERS TO MAXIMIZE THE DEVELOPMENT OF THE MOST SUITABLE SITES, WHICH INCLUDE THOSE WITH BEST SLOPES, BEST SOIL FOR SEPTIC SYSTEMS, BEST ACCESSABILITY OR BEST VIEWS, WHILE AT THE SAME TIME PRESERVING UNIQUE FEATURES SUCH AS WOODLANDS, WETLANDS OR WILDLIFE HABITAT. DEVELOPERS CAN SET THESE ASIDE AS PERMANENT, COMMON OPEN SPACE.

CLUSTERS OF HOUSES MAY BE GROUPED AROUND CUL-DE-SACS, WHERE THROUGH-STREET TRAFFIC - THE DOMINANT THEME OF THE GRIDIRON SUBDIVISION - IS ELIMINATED. OR THEY MAY BE GROUPED AROUND COMMONLY-OWNED GREEN SPACES WITH PARKING IN THE REAR.

THE BENEFITS OF CLUSTER DESIGNS ARE MOST OBVIOUS WHEN WALKING THROUGH AN EXISTING CLUSTER DEVELOPMENT. IN COMPARISON WITH THE GRID SUBDIVISION, STREETS ARE QUIETER, HAVE LESS TRAFFIC, MORE TREES AND GREENERY, AND CHILDREN HAVE EXTENSIVE OPEN AREAS NEARBY FOR PLAY. RESIDENTS NOT ONLY ENJOY THE DECREASED PERSONAL PROPERTY MAINTENANCE OF THEIR OWN YARD, BUT ALSO BENEFIT FROM THE PRESERVATION OF LARGE ADJACENT GREEN SPACES.

ECONOMICALLY, THE CLUSTER SUBDIVISION HAS PROVEN TO BE MORE PRACTICAL THAN GRIDIRON DEVELOPMENT. MOST OF THE CAPITAL IMPROVEMENTS IN A SUBDIVISION CONSIST OF SUCH COSTLY PROCEDURES SUCH AS BUILDING ROADS, STORM DRAINS, SIDEWALKS, STREET LIGHTING AND LAYING UNDERGROUND UTILITIES. THE EXPENSE OF THESE IS OF COURSE REFLECTED IN THE PRICE POTENTIAL RESIDENTS WILL PAY FOR THEIR LOTS; THE MORE EXPENSIVE THE IMPROVEMENTS, THE MORE THE BUYER WILL PAY. CLUSTER DESIGN CONSIDERABLY REDUCES THE LENGTH OF STREETS AND UTILITY LINES REQUIRED TO SERVICE AN EQUAL NUMBER OF HOUSES IN A GRID SUBDIVISION. LOOK NOW AT GUIDESHEET # 2 G. S. # 2
AND COMPARE THE TWO DIFFERENT DESIGNS FOR APPROXIMATELY THE SAME NUMBER OF HOMES ON THE SAME PIECE OF PROPERTY. (PAUSE) THE DESIGNS CLEARLY SHOW THE ECONOMIC AND OPEN SPACE BENEFITS ASSOCIATED WITH CLUSTER DEVELOPMENTS.

ONE LAST POINT ABOUT CLUSTER DEVELOPMENTS CONCERN DENSITY. WHEN THE CLUSTER WAS FIRST BROUGHT TO POPULAR ATTENTION, IT WAS ASSUMED THAT SMALLER LOTS AUTO-

MATICALLY LED TO HIGHER DENSITY. A CLUSTER ZONING ADVOCATE MAY DISPROVE THIS ASSUMPTION BY STATING THAT A DEVELOPER CANNOT BUILD MORE HOMES THAN PROVIDED FOR BY THE EXISTING ZONING EXISTS IN A CERTAIN PART OF TOWN, AND A DEVELOPER COULD BUILD FIFTY HOUSES ON A PIECE OF PROPERTY. WITH CLUSTERING THE DEVELOPER CAN STILL PUT UP ONLY FIFTY HOMES ON THAT PARCEL OF LAND. BUT EACH LOT WILL BE LESS THAN ONE ACRE, IN ORDER TO CONTRIBUTE TO THE SHARED OPEN SPACE. IN THIS WAY DENSITY LEVELS ARE NOT INCREASED, AND RESIDENTIAL SPRAWL IS CONTROLLED. (PAUSE)

NOW THAT WE HAVE A BETTER UNDERSTANDING OF RESIDENTIAL OPTIONS, LET US RETURN TO OUR INITIAL PURSUIT OF THE ATTRACTIVENESS CHARACTERISTICS OF SINGLE-FAMILY HOUSING.

THE FIRST QUESTION TO WHICH WE WISH TO ADDRESS IS: "WHAT ARE THE ACCESS REQUIREMENTS OF THE LAND USE?" A PERMANENT HOME OBVIOUSLY REQUIRES YEAR - AROUND ACCESS BY A PRIMARY ROAD - A PRIMARY ROAD BEING ONE THAT IS WELL-PAVED, MAINTAINED, AND OPEN THE ENTIRE YEAR. FOR DEVELOPMENT THAT IS TO BE FAIRLY REMOTE AND NOT IMMEDIATELY ADJACENT TO TOWN EMPLOYMENT CENTERS, ACCESS TO A MAJOR HIGHWAY IS USUALLY A REQUIREMENT. MARKET STUDIES FOR SUBURBAN HOUSING DEVELOPMENTS HAVE INDICATED THAT PEOPLE WILL COMMUTE UP TO, BUT GENERALLY NO MORE THAN, ONE HOUR'S DRIVING TIME ON LIMITED - ACCESS HIGHWAYS. BEING RELATIVELY CLOSE TO AN ON-RAMP OR INTERCHANGE IS AN IMPORTANT LOCATIONAL CRITERIA.

PROXIMITY REQUIREMENTS CONSTITUTE THE SECOND ISSUE TO BE STUDIED. BEING IN A NEIGHBORHOOD IS HIGH ON THE PRIORITY LISTS OF MOST PEOPLE. THEY LIKE TO FEEL THAT THEY ARE PART OF A COMMUNITY. SO BEING CLOSE TO OTHER HOUSING, ESPECIALLY SINGLE-FAMILY HOUSING IS GENERALLY A REQUIREMENT. THE SUPPORTIVE SERVICES THAT FAMILIES NEED INCLUDE SCHOOLS, MUNICIPAL AND RECREATIONAL FACILITIES, AND TRANSPORTATION AND COMMERCIAL SERVICES. PROXIMITY TO EMPLOYMENT AREAS, IS NOT NECESSARILY IMPERATIVE. PEOPLE ARE WILLING TO TRADE OFF PROXIMITY TO EMPLOYMENT AREAS FOR OTHER AMENITIES. LAND USES THAT ARE GENERALLY NOT COMPATIBLE IN CLOSE PROXIMITY TO SINGLE FAMILY HOUSING ARE INDUSTRY, TRAILER PARKS, COMMERCIAL SITES, TOURIST ACCOMODATIONS, AND PUBLIC UTILITIES SUCH AS SANITARY LANDFILL OR SEWAGE TREATMENT PLANTS.

FINALLY WE LOOK AT THE SITE CHARACTERISTICS THAT SINGLE-FAMILY HOUSING REQUIRES. A HOUSE REQUIRES A FOUNDATION. A FOUNDATION, AS WE DISCUSSED IN THE BUILDABILITY SECTION OF THIS UNIT, REQUIRES ADEQUATE SOIL CHARACTERISTICS TO INSURE STABILITY AND SUPPORT. A WELL-DRAINED SOIL ON FLAT OR GENTLY UNDULATING TOPOGRAPHY IS SUITABLE. PEOPLE WHO LIVE IN THE HOUSE REQUIRE WATER AND SEWAGE disposal. These needs can be met in either of two ways; by the site itself or by the town. If the site cannot meet the demand, then proximity to municipal water and sewage systems becomes a consideration.

The visual quality of the landscape is often deemed an important site requirement to enhance the quality of life for the inhabitants of a development. Hillsides with long views, lowlands with magnificent views of the mountains, or the interface between a meadow and a forest are sites that make living quite satisfying and exciting.

At this point, you have a list of the locational criteria that are appropriate. We have summarized the locational criterea on guide sheet # 4. G. S. # 4

Now you can proceed on your own and evaluate various parcels of land in your town that are available for development in terms of their attractiveness for single-family housing. This is a difficult task but one which many towns must undertake in order to prepare master plans and zoning ordinances. As you proceed with your questioning and evaluation of potential development parcels, record your findings on acetate overlay sheets. As we proceed through the unit, we will assess the attractiveness of sites for other land uses. Use separate sheets of acetate to indicate attractive areas. You should use a different color or symbol for each data category or land use. Look at Guide sheet # 5 for guidance. Mark out all areas which appear to be attractive sites for single family housing. G. S. # 5

We will move on to discuss multi-family residential developments. We will move much faster now that you have an understanding of the approach. Turn to guide sheet # 6. G. S. # 6

Multiple family dwellings include apartments, townhouses or other buildings designed for occupancy, in separate living spaces, by more than one family for permanent year-round residency. This does not include hotels and motels.

The locational criteria are very similiar to single-family housing, except in high-rise development situations. In terms of access, multi-family housing requires year-found access by a primary road. In suburban areas, accessibility to a limited-access highway is also important.

Multi-family dwellings often cater to specific segments of the population, such as single people, elderly, or married couples without children. In each of these cases there will be particular proximity requirements. For example, single and elderly people might want, to be in very close proximity to supporting services, while married couples with or without children may prefer to be in a more remote setting with easy access to the services. Regardless of these

SPECIAL DISTINCTIONS, WE CAN MAKE SOME GENERALIZATIONS ABOUT PROXIMITY NEEDS OF MULTI-FAMILY HOUSING. RESIDENTS OF MULTI-FAMILY HOUSING PREFER TO BE NEAR RETAIL AREAS, MUNICIPAL FACILITIES AND ACTIVE RECREATIONAL SITES. THEY DON'T LIKE TO BE CLOSE TO TRAILER PARKS, INDUSTRIAL USES OR SANITARY LANDFILLS.

SITE REQUIREMENTS FOR MULTI-FAMILY HOUSING ARE SIMILAR TO THOSE OF SINGLE FAMILY HOUSING. HOWEVER FOUNDATION REQUIREMENTS ARE SOMEWHAT MORE CRITICAL SINCE THE BUILDING MASS IS GREATER. SEPTIC TANK SYSTEMS ARE NOT GENERALLY USED FOR MULTI-FAMILY DWELLINGS SO AVAILABILITY OF MUNICIPAL WATER AND SEWAGE COLLECTION IS ESSENTIAL.

REFER TO GUIDE SHEET # 7 AS WE MAP OUT THOSE AREAS, THAT ARE ATTRACTIVE FOR MULTI-FAMILY HOUSING. IF YOU WOULD LIKE TO HAVE MORE TIME TO STUDY GUIDE SHEETS 6 & 7 (PAUSE) TURN OFF THE RECORDER. G. S. # 7

NOW, LET US CONSIDER COMMERCIAL LAND USES. UNDER THIS CATEGORY WE INCLUDE BUSINESSES THAT ARE INVOLVED IN THE SALE OR RENTAL OF GOODS, SERVICES OR COMMODITIES, EITHER ON A RETAIL OR WHOLESALE BASIS; INDOOR RECREATION AND ENTERTAINMENT ACTIVITIES; AND BUSINESS OR PROFESSIONAL OFFICES. REFER TO GUIDE SHEET # 8. G. S. # 8

COMMERCIAL USES TEND TO BE GROUPED TOGETHER IN VARIOUS PATTERNS. THE CLUSTERING OF INDIVIDUAL STORES IS A FAMILIAR SIGHT ALONG COUNTRY ROADS, WHERE WE FIND THE GAS STATION, DINER, GROCERETTE, AND ANTIQUE SHOP ALL NESTLED TOGETHER IN A CLEARING IN THE WOODS. OR WE MIGHT CONSIDER ANY TOWN CENTER AS A LARGE CLUSTER OF INDIVIDUAL STORES.

ANOTHER FAMILIAR PATTERN TO US IS THE STRIP OR ROADSIDE DEVELOPMENT. THESE ARE THE LONG, SEEMINGLY ENDLESS, STRETCHES OF ROAD LITTERED WITH EVERY IMAGINABLE KIND OF COMMERCIAL SERVICE, EACH ONE ARROGANTLY SHOUTING OUT ITS VIRTUES WITH A FLASHY, GLARING SIGN OR BILLBOARD.

A MORE RECENTLY DEVELOPED PATTERN OF COMMERCIAL USE IS THE SHOPPING CENTER - INDOOR AS WELL AS OUTDOOR. THE SHOPPING CENTER IS A LARGE PLANNED AGGREGATION OF COMMERCIAL USES. USES THAT OFTEN COMPRISE A SHOPPING CENTER ARE DEPARTMENT STORES, RESTAURANTS, SUPERMARKETS, CINEMAS, RECREATION FACILITIES AND EVEN SCHOOLS. SHOPPING CENTERS MAY EXPAND IN KEEPING WITH A DEVELOPMENT PLAN, BUT THEY DO NOT GROW IN A PIECEMEAL FASHION AS STRIP DEVELOPMENT DOES.

THE MOST IMPORTANT LOCATIONAL CRITERIA FOR ANY COMMERCIAL DEVELOPMENT IS ACCESS. IT MUST BE ACCESSIBLE ALL YEAR-ROUND AND HAVE PRIMARY ROAD FRONTAGE. ROAD FRONTAGE IS ESSENTIAL TO MAXIMIZE VISIBILITY FROM THE HIGHWAY OR ROAD. COMMERCIAL USES ARE ONE OF THE FEW LAND USES THAT REQUIRE HIGH VISIBILITY. IT IS CRUCIAL TO COMMERCIAL VIABILITY. ACCESS IS NOT ONLY IMPORTANT FROM THE CUSTOMER VIEWPOINT BUT FOR SERVICE AS WELL. ALL RETAIL STORES NEED TO REPLENISH

THEIR SUPPLY OF GOODS FROM THEIR DISTRIBUTORS. LARGE, REGIONAL SHOPPING CENTERS ARE GENERALLY LOCATED NEAR HIGHWAY INTERCHANGES TO OPTIMIZE THIS ACCESSIBILITY TO CUSTOMERS AND SERVICE VEHICLES.

ANOTHER IMPORTANT PROXIMITY REQUIREMENT IS PARKING. A SHOPPING CENTER HAS PARKING INTEGRATED IN ITS CONCEPT, BUT LOCAL COMMERCE HAS A MORE DIFFICULT TIME WITH FINDING SUFFICIENT PARKING SPACE.

COMPATIBLE LAND USES DIFFER WITH DIFFERENT TYPES OF COMMERCE. COMMUNITY FACILITIES AND SERVICES, TEND TO CLUSTER AROUND MOST COMMERCIAL AREAS AND RELATE AS GOOD NEIGHBORS. INDUSTRIAL PARKS CONSISTING OF "CLEAN", NON-MANUFACTURING INDUSTRIES, ARE ALSO COMPATIBLE NEIGHBORS FOR COMMERCIAL LAND USES.

THE SITE REQUIREMENTS FOR COMMERCIAL DEVELOPMENT ARE STRAIGHT-FORWARD. FLAT, OPEN LAND WITH PLENTY OF ROOM FOR EXPANSION AND LOW SITE DEVELOPMENT COSTS ARE CLEARLY THE MOST ATTRACTIVE LOCATIONS FOR DEVELOPMENT. WATER, SEWAGE, AND SOLID WASTE FACILITIES MUST BE AVAILABLE FROM THE TOWN.

NOW SURVEY YOUR TOWN FOR POTENTIAL COMMERCIAL DEVELOPMENT SITES. CONSIDER ALL OF THE REQUIREMENTS WE HAVE DISCUSSED. REFER TO GUIDE SHEET # 8 AND REVIEW THESE CRITERIA. THEN, STUDY THE EXAMPLE OF MAPPING ON GUIDE SHEET # 9. G. S # 9 MAP OUT AREAS THAT YOU HAVE DISCOVERED THAT ARE SUITABLE FOR COMMERCIAL DEVELOPMENT. (PAUSE)

COMMUNITY FACILITIES AND SERVICES, AS A LAND USE CATEGORY, INCLUDE A DIVERSE NUMBER OF ACTIVITIES. THIS MAKES DISCUSSING LOCATIONAL CRITERIA DIFFICULT BUT THERE ARE GENERALIZATIONS THAT WE CAN MAKE THAT APPLY TO MOST OF THE ACTIVITIES. WHAT WE MEAN BY "COMMUNITY FACILITIES" ARE THOSE NON-COMMERCIAL ACTIVITIES WHICH SERVE THE PUBLIC, AND ARE OWNED AND OPERATED BY PUBLIC BODIES OR AGENCIES. THIS LAND USE CLASSIFICATION IS ALSO COMMONLY REFERRED TO AS "INSTITUTIONAL". RELIGIOUS OR CHARITABLE ORGANIZATIONS, SCHOOLS, POLICE, FIRE STATIONS, POST OFFICES, AIRPORTS AND CEMETARIES ARE ALL INCLUDED IN THIS CATEGORY.

ACCESS IS THE MOST IMPORTANT LOCATIONAL CRITERIA FOR INSTITUTIONAL LAND USES. YEAR-ROUND ACCESS ON A PRIMARY ROAD IS ESSENTIAL TO ENABLE THE PUBLIC TO REACH THE FACILITY OR, MORE IMPORTANTLY, IN THE CASE OF POLICE, FIRE AND MEDICAL SERVICES, FOR THE FACILITY TO REACH THE PEOPLE. ACTUAL ROAD FRONTAGE IS A REQUIREMENT FOR MANY OF THESE SERVICES.

PROXIMITY TO THE COMMUNITY THAT IT SERVES, IS AN IMPORTANT REQUIREMENT FOR A FACILITY. CHURCHES, SCHOOLS, AND FIRE STATIONS SHOULD BE, AND USUALLY ARE WELL-INTEGRATED INTO PERMANENT RESIDENTIAL AREAS. INSTITUTIONAL USES ARE, THEMSELVES, NOT INCOMPATIBLE WITH MOST OTHER USES, BUT FREQUENTLY THE DESIGN OF THE FACILITIES MIGHT ESTABLISH AN INCOMPATIBLE RELATIONSHIP WITH SURROUNDING USES.

THERE ARE SOME SITUATIONS WHERE AN INCOMPATIBILITY BETWEEN USES MIGHT EXIST. FOR EXAMPLE A COMMUNITY COLLEGE WITH HUNDREDS OF COMMUTING STUDENTS SHOULD NOT BE LOCATED WITHIN A DENSE RESIDENTIAL AREA. TRAFFIC DANGERS FOR SMALL CHILDREN LIVING IN THE AREA WOULD BE SEVERE. CHURCHES ARE NOT GENERALLY CONSIDERED COMPATIBLE WITH COMMERCIAL OR INDUSTRIAL USES, BUT A POST OFFICE OR POLICE STATION, WHICH ARE ALSO INSTITUTIONAL USES, ARE COMPATIBLE IN THOSE ZONES. SO, RECOGNIZING THE DIVERSITY OF ACTIVITIES UNDER THIS LAND USE CATEGORY, WE MUST LOOK AT EACH POTENTIAL RELATIONSHIP INDEPENDENTLY AND EVALUATE IT WITH THE UNDERSTANDING THAT CENTRALITY AND PROXIMITY TO POPULATION CENTERS ARE IMPORTANT UNDERLYING REQUIREMENTS.

CREATING A ZONE OF INSTITUTIONAL USES MIGHT ALLEVIATE A VARIETY OF INCONVENIENCES. FOR INSTANCE, IMAGINE A ZONE THAT INCLUDES THE POLICE AND FIRE STATIONS, A HOSPITAL, POST OFFICE, MOTOR VEHICLES BUREAU, ARMED SERVICES OFFICES AND MUNICIPAL FACILITIES OFFICES. COMMUNICATION AMONG THESE SERVICES WILL BE INCREASED AND CITIZENS WILL HAVE AN EASY TIME FINDING A SPECIFIC FACILITY BECAUSE THEY WILL KNOW THAT IT IS WITHIN THE ZONE. SMALL TOWNS OFTEN HAVE AN INSTITUTIONAL ZONE . . . THE TOWN CENTER! HOWEVER, IN GROWING SUBURBAN COMMUNITIES, SERVICES TEND TO BE SCATTERED AND UNRELATED. REFER NOW TO GUIDE SHEET #10 FOR A DIAGRAM ILLUSTRATING HOW THESE ZONES CAN GIVE FORM TO OFTEN FORMLESS COMMUNITIES. G. S. # 10

SITE REQUIREMENTS FOR INSTITUTIONAL USES GENERALLY CALL FOR SITES THAT ARE OPEN AND FLAT. CEMETARIES, SCHOOLS, COLLEGES AND EVEN CHURCHES ARE EXCEPTIONS WHICH CAN BE DEVELOPED IN AREAS WITH SOME ENVIRONMENTAL DIVERSITY, SUCH AS HILLS AND WOODED AREAS, TO ENHANCE THEIR CHARACTER AND IMAGE.

NOW, LET'S DEFINE THOSE AREAS IN OUR THEORETICAL TOWN THAT ARE ATTRACTIVE FOR INSTITUTIONAL FACILITIES. REFER TO GUIDE SHEET #11 AND MAP OUT THE AREAS THAT ARE ATTRACTIVE FOR INSTITUTIONAL DEVELOPMENT. STOP THE RECORDER WHILE YOU CARRY OUT THIS ACTIVITY. G. S. # 11

LET'S CONSIDER INDUSTRIAL LAND USES NEXT. THERE ARE ESSENTIALLY THREE TYPES OF INDUSTRY - LIGHT INDUSTRY, HEAVY INDUSTRY AND EXTRACTION INDUSTRY.

LIGHT INDUSTRY REFERS TO NON-POLLUTING, NON-WASTE PRODUCING INDUSTRIES. THIS INCLUDES COMPANIES INVOLVED IN THE MANUFACTURING, PRODUCTION, ASSEMBLY, AND DISTRIBUTION OF GOODS AND MATERIALS. THE MANAGING OF THE COMMODITY DOES NOT CREATE LARGE AMOUNTS OF WASTE OR RESIDUAL MATERIAL, SUCH AS SMOKE CONTAINING HIGH CONCENTRATIONS OF AIR POLLUTANTS OR EFFLUENT THAT NEEDS TO BE DISCHARGED INTO A BODY OF WATER. LIGHT INDUSTRY IS CHARACTERIZED BY TRUCKING COMPANIES, bottling plants, container and packaging operations and the so-called "clean industry" which are industrial parks comprised of industry offices and headquaters.

Heavy industry is also involved in the manufacturing, production and assembly of goods and materials. But, in contrast to light industry, the scale of operation is quite different. Heavy industries usually require large facilities and process large quantities of materials. Pollutants and waste-by products are normally companions of the operation. Steel mills, lumber mills, and chemical producers are generally listed as heavy industries. Historically, heavy industry has been a major source of air and water pollution. Many of these industries are working hard on pollution abatement programs.

The extraction industry involves the extraction of materials from the land. Sand, gravel, coal, various rick types and, minerals used in the production of metals and other commodities are commonly extracted materials.

Mining and extractive industries have become the focal point of much controversy. Companies that participate in mining and extractive industry have historically been very insensitive to the land. "Strip-mining" is a commonplace procedure for these industries. Strip-mining involves stripping the land of all vegetation and topsoil, extracting whatever quantities of the desired material are available, and leaving the area when the operation is complete. Thousands of acres of land are torn up and left useless in the United States each year by these operations. Presently attempts are being made to reclaim some of these lands as recreation areas by filling them and trying to restore vegetative cover. Federal legislation is being developed that would prohibit a company from performing any extraction without having plans from the reclamation of the land. This would place the financial burden of reclamation on the industry rather than on the owner of the land.

These industry types have different locational criteria, since they have sufficiently different characteristics.

For light industry, access is a particularly important criterion. Receiving and distributing goods requires year-round access by a primary road. In many cases primary roads must lead directly to a major highway for regional service. Many companies not only service their local towns, but they receive their parts from distant manufactures. Heavy industry has the same access requirements as light industry. It also needs to be easily reached by its suppliers and must

BE ABLE TO REACH ITS DISTRIBUTORS. BOTH HEAVY AND EXTRACTIVE INDUSTRIES REQUIRE ACCESS TO PRIMARY ROADS THAT ARE SEPARATED FROM RESIDENTIAL AND LOCAL TRAFFIC TO AVOID INCONVENIENCE AND CONGESTION. FOR THIS REASON, THESE INDUSTRIES TEND TO BE ISOLATED.

ISOLATION IS THE MAJOR PROXIMITY REQUIREMENT FOR MOST TYPES OF INDUSTRY. OTHER LAND USES PREFER NOT TO BE CLOSELY ASSOCIATED WITH INDUSTRY, EVEN LIGHT INDUSTRY. NEW, WELL-LANDSCAPED, CLEAN-INDUSTRY, INDUSTRIAL PARKS; HOWEVER, ARE MORE ACCEPTED AS NEIGHBORS FOR COMMERCIAL OR COMMUNITY FACILITY USES.

ANOTHER IMPORTANT REQUIREMENT FOR ALL INDUSTRIES IS ACCESSIBILITY TO THE LABOR MARKET. THIS DOES NOT NECESSARILY INDICATE A SPATIAL RELATIONSHIP - THE EMPLOYEES DO NOT HAVE TO LIVE NEAR THE FACTORY. THE ACCESS CRITERION OF BEING LOCATED ON OR NEAR A MAJOR HIGHWAY OR ON MASS TRANSPORTATION ROUTES SHOULD SUBSTITUTE ADEQUATELY FOR PHYSICAL PROXIMITY.

MUNICIPAL WATER AND SEWER SERVICE ARE PROXIMITY REQUIREMENTS FOR BOTH LIGHT AND HEAVY INDUSTRY. ON-SITE UTILITIES, IN MANY CASES, CAN'T ACCOMODATE THE DEMAND AND LOAD CREATED BY LARGE COMPANIES. SEWER FACILITIES ARE ESPECIALLY IMPORTANT IN SITUATIONS WHERE CHEMICAL BY-PRODUCTS MUST BE DISPOSED OF. PUMPING UNUSUAL CHEMICALS INTO THE SOIL OR A RIVER CAN HAVE VERY SERIOUS IMPACTS ON THE ECOLOGICAL STATUS OF THE AREA AND SHOULD NOT BE TOLERATED. A SEWAGE SYSTEM WITH ADEQUATE TREATMENT FACILITIES IS A PLANNING NECESSITY.

BOTH LIGHT AND HEAVY INDUSTRY REQUIRE FLAT OPEN SITES. LOW SITE COSTS ARE USUALLY IMPORTANT CONCERNS. A SITE THAT IS FLAT AND WITHOUT ANY LARGE VEGETATION CAN BE BUILT UPON EASILY AND INEXPENSIVELY PROVIDING THAT FOUNDATION CONDITIONS ARE SUITABLE. AREAS WITH SHALLOW BEDROCK OR HIGH WATER TABLE CONDITIONS SHOULD GENERALLY BE AVOIDED.

THE SITE REQUIRED FOR AN EXTRACTIVE INDUSTRY NATURALLY DEPENDS ON THE LOCATION OF THE RESOURCE DESIRED. THIS IS THE MOST IMPORTANT LOCATIONAL CRITERION FOR THAT TYPE OF INDUSTRY.

REFER, NOW TO THE GUIDE SHEET # 12 FOR A REVIEW OF INDUSTRIAL ATTRACTIVE-
NESS CRITERIA. LOCATE AREAS WITHIN YOUR OWN TOWN WHICH WOULD PROVIDE ATTRACTIVE G. S. # 12
SITES FOR INDUSTRIAL DEVELOPMENTS. LOCATE THEM ON A TOWN MAP. LOOK AT THE
SAMPLE ON GUIDE SHEET # 13. G. S. # 13

WE WILL NOW DISCUSS SOLID WASTE DISPOSAL AS A LAND USE UNDER THE GENERAL CATEGORY OF UTILITIES.

SOLID WASTE IS ANOTHER NAME FOR REFUSE. REFUSE IS ANOTHER NAME FOR THE MORE COMMON TERMS - GARBAGE AND RUBBISH. YOU MAY NOT KNOW IT, BUT THER IS A DIFFERENCE BETWEEN THE TWO.

Garbage is waste consisting of animal and vegetable scraps, left over from the preparation, cooking and serving of foods.

Rubbish or trash is waste consisting of combustible paper products and wood products, and non-combustible metals, glass and minerals.

Refuse again, is garbage, rubbish and any other type of waste.

Try and imagine how much refuse you produce each day. Consider all of the food you leave left over on your plate; the packages that the food came in; the empty coke bottles; the evening newspaper, the gift wrappings you don't want to save. How much do you suppose all of that adds up to? Well, a national survey in 1968 showed the average amount of waste was over 5.5 pounds per person per day. The fiture is much higher today. But even then, that is 2000 pounds or 1 ton of refuse per person per year. Multiply that by 200 million people in the United States and that's a lot of refuse. What do we do with all of that solid waste?

Well, there are several ways we can dispose of solid waste. One is to burn it, but that produces a lot of air pollution and not everything burns. The non-combustible residue method, then, requires two steps - burning and burying.

There is composting in this process. Paper, rags, metals, glass and plastics are removed from the solid waste stream, and the organic material which is left is composted and used as fertilizer. As you can imagine, this is a costly process and still requires doing something with the inorganic materials.

Landfilling is the most common and effective method of dealing with solid waste disposal. A sanitary landfill is a method of disposing of solid wastes without creating nuisances or hazards to public health by utilizing engineering principles. Mixed refuse is compacted and covered daily with at least 6 inches of dirt which is compacted to produce a tight seal. The seal prevents flies from breeding, stops rodents from invading the fill, seals in odors, and keeps loose refuse from blowing onto roads or adjoining property. A properly designed and operated sanitary land fill produces no ground or surface water pollution and there is no burning to create air pollution.

Sanitary landfills are far more economical than other disposal methods. The initial capital costs including costs of site acquisition and preparation are roughly one fourth to one half the costs for incineration or compositing. Operating costs for landfills are approximately one third to one half of those for these other methods. Moreover, the improvement of property is one of the

CHIEF ECONOMIC ADVANTAGES OF THE SANITARY LANDFILL METHOD. LAND USES OF COMPLETED LANDFILLS INCLUDE ATHLETIC FIELDS, BOTANICAL GARDENS, GOLF COURSES, PARKING LOTS, PLAYGROUNDS, RUNWAYS AND TRAILER PARKS.

THE MAJOR DRAWBACK TO THE SANITARY LANDFILL METHOD IS THE REQUIREMENT FOR LAND. IN TOWNS WHERE THERE ARE NOT AREAS THAT CAN BE RECLAIMED, SUCH AS OLD QUARRY PITS, NEW LAND HAS TO BE ALLOCATED FOR THIS PURPOSE. DUE TO THE CONSIDERABLE AMOUNT OF WASTE PRODUCED, LARGE PARCELS OF LAND ARE NEEDED TO SATISFY THE DEMAND. AT 5.5 POUNDS/PER PERSON PER DAY, 2 CUBIC YARDS OF COMPACTED FILL SPACE IS NEEDED PER PERSON FOR ONE YEAR. IN LARGE COMMUNITIES THIS CONSUMES QUITE A BIT OF LAND.

IF A LAND FILL IS TO BE USED FOR SOILED WASTE DISPOSAL, WHERE SHOULD IT BE LOCATED? LET'S TURN NOW TO THE ATTRACTIVENESS CRITERIA FOR A SANITARY LANDFILL. THE ATTRACTIVENESS CRITERIA ARE OUTLINED ON GUIDE SHEET # 14. G. S. # 14

ACCESS IS AN IMPORTANT CRITERION FOR A LANDFILL. A PRIMARY ROAD THAT IS OPEN YEAR-ROUND IS ESSENTIAL TO FACILITATE ENTRY OF THE TOWNSPEOPLE AND MUNICIPAL TRUCKS TO THE SITE.

IN REGARD TO PROXIMITY REQUIREMENTS, THE LANDFILL SHOULD BE SOMEWHAT CENTRALLY LOCATED TO THE SOURCES OF REFUSE. THE GREATER THE DISTANCE FROM THE SOURCE TO THE SITE, THE MORE THE OPERATING EXPENSES WILL GO UP. ISOLATION IS HOWEVER, USUALLY A LOCATIONAL CRITERION.

MOST LAND USES DO NOT CONSIDER A LANDFILL, REGARDLESS OF HOW SANITARY IT IS, TO BE A COMPATIBLE NEIGHBOR.

THE SITE REQUIREMENTS FOR A LANDFILL ARE VERY STRINGENT, TO AVOID SERIOUS ENVIRONMENTAL IMPACT. AS THE REFUSE OF THE LANDFILL DECOMPOSES, THE DIVERSE CHEMICAL CONTENTS WILL FILTER DOWN THROUGH THE SOIL, JUST AS IN A SEPTIC TANK LEACHING FIELD. IF THE LANDFILL IS IMPROPERLY SITED, GROUND AND NEIGHBORING SURFACE WATER HAVE THE POTENTIAL TO BECOME CONTAMINATED. TO AVOID SUCH IMPACTS, A LANDFILL SHOULD BE LOCATED WITH THESE GUIDELINES IN MIND: 1. NO LAKES OR RESERVOIRS SHOULD BE WITHIN ONE MILE, DOWN DRAINAGE FROM THE SITE; 2. WATER WELLS SHOULD NOT BE WITHIN 1000 FEET OF THE SITE; 3. THERE SHOULD BE A MINIMUM OF SURFACE DRAINAGE ENTERING THE LANDFILL AREA; 4. THERE SHOULD BE NO SPRINGS OR WET AREAS WITHIN THE SITE; 5. THE LANDFILL SHOULD NOT BE OVER OR ADJACENT TO AN AQUIFER. 6. HIGH WATER TABLE AREAS SHOULD BE DEFINED AS UNSUITABLE FOR LANDFILL LOCATIONS.

ANOTHER IMPORTANT SITE AND PROXIMITY REQUIREMENT, IS THE AVAILABILITY OF COVER MATERIAL. SOIL IS NEEDED AT THE END OF EACH DAY TO COVER OVER THE REFUSE. HAVING A PLENTIFUL SOURCE OF MATERIAL ON THE SITE WILL ELIMINATE THE

EXPENSE OF IMPORTING IT FROM AN OFF-SITE SOURCE. THE COVER MATERIAL MUST BE FREE OF SUBSTANCES THAT ATTRACT FLIES AND RODENTS, FREE OF LARGE OBJECTS THAT MIGHT HINDER SPREADING AND COMPACTION, AND SHOULD NOT BE EASILY ERODED BY WATER OR WIND. THE FINAL COVER MATERIAL SHOULD BE ABLE TO SUPPORT VEGETATION, UNLESS THE LANDFILL IS TO BE USED FOR A STRUCTURE OR ROAD. SANDY LOAM IS OFTEN THE MOST RECOMMENDED DAILY COVER MATERIAL.

NOW THAT WE HAVE REVIEWED THE ATTRACTIVENESS CRITERIA FOR A SANITARY LANDFILL, LET'S BEGIN TO LOCATE SOME SUITABLE SITES ON OUR OVERLAYS. LOOK AT GUIDE SHEET # 14 FOR A REVIEW OF LANDFILL SITING CRITERIA AS WELL AS A SAMPLE MAP ON GUIDE SHEET # 15 . TURN OFF THE RECORDER WHILE YOU CARRY OUT THIS ACTIVITY. G. S. # 15

ANOTHER APPROACH TO SOLID WASTE MANAGEMENT IS THE IMPOSITION OF REGULATORY MEASURES AFFECTING THE QUANTITY OF WASTE PRODUCED BY YOU AND ME. LEGISLATION CANNOT RESTRICT PEOPLE FROM BUYING THINGS, BUT IT CAN PROHIBIT THE SALES OF CERTAIN GOODS. IN OREGON, FOR EXAMPLE, IT IS ILLEGAL TO SELL NON-RETURNABLE BOTTLES OR CANS. THIS REGULATION HAS REDUCED LITTER ON THE HIGHWAYS BY OVER 90% AND HAS REMOVED A LARGE VOLUME OF WASTE FROM THE SOLID WASTE STREAM, THUS DECREASING THE DEMAND FOR LANDFILL SITES. THIS TYPE OF LEGISLATION MIGHT PROVE TO BE THE MOST EFFECTIVE WAY TO REDUCE CONSUMPTION OF LAND FOR LANDFILL SITES, AND ENHANCE ENVIRONMENTAL QUALITY.

FINALLY, WE COME TO RECREATION AND CONSERVATION AS LAND USE CATEGORIES. LAND THAT IS INVOLVED IN THESE USES FALL UNDER THE HEADING OF OPEN SPACE, REFER TO THE UNIT ON OPEN SPACE FOR A DISCUSSION OF THE FUNCITONS AND VALUES OF OPEN SPACE. WE CAN TALK ABOUT TWO TYPES OF RECREATIONAL LAND USE - LOCAL AND REGIONAL. CONSERVATION IS NOT GENERALLY SEEN AS A LAND USE IT IS MORE OF A POLICY OF RESOURCE MANAGEMENT.

OPEN SPACE RECREATION CAN BE DEFINED AS ACTIVE RECREATIONAL USE PARTICULARLY ORIENTED TO AND UTILIZING THE OUTDOOR CHARACTER OF AN AREA. THESE AREAS INCLUDE PLAYGROUNDS, PICNIC AREAS, PARKS, PUBLIC BEACHES, MARINAS OR BOAT LAUNCHING SITE, BICYCLE OR HORSE RENTAL FACILITIES AND OTHER SIMILIAR USES AND ACTIVITIES. ALL OF THESE ACTIVITIES CAN BE EITHER LOCALLY OR REGIONALLY ORIENTED.

LOCAL RECREATIONAL LAND USES ARE DESIGNED TO SERVICE AND MEET THE NEEDS OF A TOWN OR LOCAL POPULATION. THE SCALE AND SIZE OF THESE FACILITIES IS DESIGNED TO SATISFY THE NEEDS OF THE IMMEDIATE NEIGHBORHOOD. REGIONAL RECREATIONAL LAND USES CAN INCLUDE THE SAME TYPE OF ACTIVITIES AS LOCAL RECREATIONAL USES, BUT THEY ARE INTENDED TO MEET THE NEEDS OF A GREATER NUMBER OF PEOPLE. A REGIONAL PARK, FOR INSTANCE, IS INTENDED TO SERVE MANY TOWNS RATHER THAN THE RESIDENTS OF A SINGLE TOWN.

Locational criteria for recreational land uses vary depending on the specific recreation type. However, there are some generalizations that we can make about the two categories - local and regional recreation.

Local recreation activities should be well-dispersed throughout a town. The amount of open space should be directly correlated with residential densities. Areas with higher densities should have more accessible open space than low density areas. Access to the recreation area should not be dangerous. Ideally, pedestrian walks or bikeways should link the various open space areas together. The links or corridors should be continuous, with a limited number of street crossings.

Historically open space has been poorly planned for - open space in most communities is generally space that is left over. Parks and playgrounds are often built on land left over by major hishway development. Not only is this land less-than-ideal because of the noise level from passing traffic, but the passing traffic presents a hazard to children and adults using the facility.

Recently, with the growing emphasis on recreation and leisure-time activities, more desirable land is being sought for recreational uses. Open-space corridors are being developed to provide for safety of movement between these spaces as well as to enhance the recreation experience. Refer to the guide sheet # 16 G. S. # 16 for an illustration of an open space system. (Pause)

Ideally, there should be some sort of local recreation activity within a one-half mile walk from any residence. It is not possible to establish guidelines for the types of activities which should be developed within the 1/2 mile radius. That depends on the population characteristics. Neighborhoods with large numbers of children should have more playgrounds than areas with older people whose children have grown up. It is also difficult to correlate a square footage figure with open space requirements. This is often done but hardly seems appropriate, considering that people have such different needs.

Regional recreation, because it is serving a large population, should be accessible by a primary road or highway. Available land for parking is a necessary requirement for a regional recreational facility. There should be sufficient parking space to carry the unusually busy days, such as holidays, when families often flock to parks and recreation areas.

Regional parks are usually set in areas with diverse and unique landscape qualities. Lakes, streams, meadows, forests, hills and valleys, all create a rich visual texture and setting for recreational enjoyment.

Regional recreation areas should also fit into an open space system. Regional parks should be linked to each other and local recreation areas. Look at the illustration on guide sheet # 17. Establishing open space networks and interlocking the different levels of recreational activity add tremendous diversity and excitement to the environmental quality of a town or region. G. S. # 17

Conservation land is usually undeveloped, forested land accomodating a variety of passive uses, all of which are compatible with the outdoor character of an area. These uses include hunting and fishing, game preserve, forest management, cross-country skiing, backpacking, horseback riding, camping and other similar activities. The areas that are best suited for these uses are also those areas that are most sensitive to environmental impact. Thus, management and restricted use policies are often associated with these areas.

Land that has been labeled unsuitable for development, during the map buildability study, for whatever reason, is land that is best suited for conservation and preservation. If you recall, these are wetlands, floodplains, steep slope areas, aquifer recharge zones, unusual or exceptional stands of trees, and other areas. Non-intensive recreation activities and conservation practices should be the only uses allocated to these sensitive areas.

Isolation from intensive development and major roads is the primary proximity and access requirements for conservation land. Wildlife will be more attracted to remote natural areas than land adjacent to land uses where people, dogs, machinery, automobiles or airplanes are present. Access to the land should be passable, to allow people to take advantage of the amenities it possesses.

Begin now to pick out those areas in your town that should be preserved as recreational or conservation land and map them on a new acetate overlay. Refer to guide sheet # 18 for an example of how the process may be carried out. Stop the recorder, while you carry out this activity. G. S. # 18

We have now concluded the discussion of attractiveness criteria for each land use category. We have generated a separate map of each land use category that outlines those areas which, according to the criteria discussed, are the most suitable or "attractive" locations for each respective land use. As with the buildability issues, we only recorded the extreme conditions. In the buildability section, we recorded only those areas that are most attractive. In both cases, there are non-extreme situations. In other words, there exist sites that have low and moderate buildability or attractiveness. We have used the extreme conditions here to clearly illustrate the process without too much complexity. We hope that the illustrations and the overlay exercises

HELPED YOU DEVELOP A CLEAR CONCEPTION OF HOW THE SYNTHESIS PROCESS WORKS AND HOW IT CAN BE VALUABLE.

REFER TO GUIDE SHEET # 19 AND LOOK AT THE EXAMPLE AS WE DESCRIBE THIS SECOND SYNTHESIS STEP. (PAUSE) G. S [illegible]9

EACH LAND USE CATEGORY HAS BEEN RECORDED ON A SEPARATE MAP AND EACH IN ITS STANDARD COLOR FOR REPRESENTATION. ON THE BASE MAP OF OUR TOWN, WE CAN OVERLAY ALL OR ANY COMBINATION OF LAND USES ON TOP OF ONE ANOTHER. AS WE "LOOK THROUGH" THE MAPS WE SEE OUTLINED AREAS THAT STAND ISOLATED AND WE SEE OTHERS WHERE THE COLORS OVERLAP. THESE ISOLATED AREAS WHERE NO TWO COLORS OVERLAP TO CREATE A THIRD, INDICATE THOSE AREAS WHERE THERE ARE NO CONFLICTS BETWEEN LAND USES. BY CHECKING THE COLOR CODE SYSTEM WE CAN DETERMINE WHAT LAND USE IS APPROPRIATE FOR EACH AREA OF THE COMMUNITY. IN THE AREAS WHERE THERE ARE MIXED AND OVERLAPPED COLORS, A CONFLICT EXISTS AND MUST BE LOOKED AT MORE CLOSELY FOR RESOLUTION. IF ONE OF THESE USES WITH MULTIPLE OPTIONS IS CONFLICTING IN ONE PLACE WITH ANOTHER USE THAT HAS NO OTHER OPTIONS, THEN THE SOLUTION IS EASY - THE MULTIPLE OPTIONED LAND USE CAN UTILIZE ONE OF THE OTHER SITES THAT IT HAS AVAILABLE. OTHER CONFLICTS MAY NOT BE AS EASY TO RESOLVE. IT MAY REQUIRE RE-EVALUATING THE SITES IN TERMS OF THE CRITERIA AND TAKING A CLOSER LOOK AT THE NEIGHBORING LAND USES OR CHARACTER OF THE AREA. THE FINAL MAP SHOULD BE A COMPOSITE MAP OUTLINING ALL OF THE ATTRACTIVE AREAS FOR EACH LAND USE, WITH AS MANY OF THE CONFLICTS WORKED OUT AS POSSIBLE. IF THERE WERE FOUR SUITABLE ZONES FOR INDUSTRY, THEY SHOULD ALL BE INDICATED. THE SAME IS TRUE FOR ALL OF THE OTHER USES. THE MAP THAT WE HAVE JUST PRODUCED IS A "LAND USE ATTRACTIVENESS MAP."

THE FINAL STEP IN THIS PROCESS INVOLVES OVERLAYING THE BUILDABILITY COMPOSITE THAT WE PRODUCED IN THE FIRST HALF OF THIS UNIT WITH THE ATTRACTIVENESS COMPOSITE THAT WE HAVE JUST COMPLETED. REFER TO GUIDE SHEET # 20 FOR AN ILLUSTRATION G. S # 20 OF THIS PROCESS. (PAUSE) LAND USES THAT FALL INTO ZONES UNSUITABLE FOR DEVELOPMENT MUST BE ELIMINATED. ALL OF THE LAND USES THAT ARE NOT LOCATED IN UNBUILDABLE AREAS ARE COMPATIBLE WITH THEIR SITES AND CAN BE CONSIDERED FOR ALLOCATION TO THOSE PLACES. DRAW A FINAL MAP OF THOSE LAND USES WITHOUT ENVIRONMENTAL CONFLICTS - THIS MAP IS CALLED THE LAND USE ALLOCATION MAP OR PLAN. NOW, WE HAVE A MAP THAT TELLS US WHERE WE CAN PUT FUTURE LAND USES THAT WILL NOT HAVE SEVERE ENVIRONMENTAL IMPACTS ON THE LAND. THE LAND USE ALLOCATION MAP GIVES US INFORMATION ON LAND USE REQUIREMENTS, IN TERMS OF ACCESS, PROXIMITY AND SITE CONDITIONS.

IF THERE ARE TOO MANY SITES ALLOCATED FOR A SPECIFIC LAND USE AND ONE OF THEM HAS TO BE SELECTED, THEN LOOK AT ALL OF THE SITES MORE CLOSELY AND RE-

EVALUATE THEM AGAIN IN TERMS OF THE LOCATIONAL CRITERIA. REMEMBER, THAT IT IS UNLIKELY THAT ANY ONE SITE WILL SATISFY COMPLETELY ALL THE CRITERIA. TRADE-OFFS WILL HAVE TO BE MADE BASED UPON A NUMBER OF FACTORS. ONE OF THOSE FACTORS, AND PROBABLY THE MOST IMPORTANT IN MOST COMMUNITIES IS ECONOMICS. REFER TO THE UNIT ON "ECONOMIC TRADE-OFFS" FOR MORE DETAILS ON THIS ISSUE. TO DEMONSTRATE HOW ECONOMICS PLAYS A ROLE IN DECISION MAKING, CONSIDER THIS ILLUSTRATION. SUPPOSE WE HAVE DISCOVERED TWO IDEAL SITES FOR A SANITARY LANDFILL. BOTH ARE ADJACENT TO A PRIMARY ROAD, BOTH ARE WELL ISOLATED, ALL OF THE STRINGENT SITE REQUIREMENTS ARE SATISFIED AND SITE PREPARATION COSTS ARE COMPARABLE. HOWEVER, ONE SITE IS A FEW MILES FURTHER FROM THE POPULATION CENTER THAN THE OTHER. THIS WOULD INCREASE HANDLING COSTS IN TERMS OF GAS, WEAR AND TEAR ON GARBAGE COLLECTION VEHICLES AND TIME TO COVER EXTRA MILES. THE CLOSER SITE, THEN, IS MORE APPROPRIATE.

ANOTHER IMPORTANT FACTOR IN RESOLVING ALLOCATION DECISIONS, IS ZONING. WE MIGHT DISCOVER A NUMBER OF IDEAL SITES FOR LIGHT INDUSTRY BUT DISCOVER THAT MANY OF THEM ARE IN AN AREA ZONED FOR COMMERCIAL USES. THERE ARE SEVERAL THINGS WE CAN DO THEN: EITHER DISREGARD THOSE SITES ALTOGETHER; ASK FOR A ZONING VARIANCE; OR CHANGE THE ZONING PLAN ALTOGETHER. IN MANY CASES, ZONING PLANS ARE BASED ON FAR LESS INFORMATION THAN WE HAVE CONSIDERED HERE. PERHAPS IT IS TIME TO REVISE OLD ZONING PLANS AND MASTER PLANS. THIS SYNTHESIS PROCESS MAY AID YOU IN REVISING ZONING REGULATIONS AND IN THE PREPARATION OF A MASTER PLAN FOR YOUR COMMUNITY.

THIS SOUND, ECOLOGICAL LAND USE PLANNING PROCESS WILL ENABLE TOWNS AND COMMUNITIES TO PREPARE THEMSELVES OR TO BETTER COPE WITH THE GROWING PRESSURES OF DEVELOPMENT AND URBANIZATION.

SYNTHESIS

RECENTLY, THE FEDERAL GOVERNMENT HAS RELEASED A STUDY ENTITLED THE COSTS OF SPRAWL. THE STUDY COMPARES THE COST OF PLANNED DEVELOPMENT WITH THE COST OF SPRAWL. THE PRIMARY INTENT OF THE STUDY WAS TO PROVIDE INFORMATION FOR USE BY LOCAL GOVERNMENT DECISIONMAKERS IN THEIR PLANNING AND DEVELOPMENT DELIBERATIONS. THE FOLLOWING QUOTE DESCRIBES THE PURPOSE OF THE STUDY:

> "LOCAL OFFICIALS ARE BEING FACED WITH INCREASINGLY DIFFICULT DECISIONS ABOUT HOW LAND SHOULD BE USED AND HOW MUCH AND WHAT TYPE OF DEVELOPMENT SHOULD BE ALLOWED. THEY ARE BEING PRESENTED PROPOSALS FOR NEW TYPES OF DEVELOPMENT THAT THEY MAY NOT HAVE DEALT WITH BEFORE; CLUSTERED SINGLE FAMILY HOUSING, TOWNHOUSES, WALKUP APARTMENTS, AND HIGH RISE APARTMENTS ARE APPEARING IN COMMUNITIES EVEN OUT TO THE URBAN FRINGE.
>
> AT THE SAME TIME, THERE IS INCREASED CONCERN ABOUT THE IMPACTS OF NEW DEVELOPMENT ON THE COMMUNITY. THIS HAS BEEN LIMITED MOSTLY TO ECONOMIC IMPACTS OF THE DEVELOPMENT - WHETHER THE ADDED TAX BASE WOULD COMPENSATE FOR THE ADDED COSTS THAT THE NEW RESIDENTS IMPOSED ON THE COMMUNITY.
>
> IN RECENT YEARS THESE ECONOMIC CONCERNS HAVE BEEN JOINED BY ENVIRONMENTAL AND OTHER CONCERNS. WHAT WILL THE DEVELOPMENT DO TO AIR POLLUTION, WATER POLLUTION, WILDLIFE, AND OPEN SPACE? WHAT IS THE IMPACT OF DEVELOPMENT UPON ENERGY CONSUMPTION? ON WATER CONSUMPTION? HOW WILL THE DEVELOPMENT AFFECT THE LIVES OF THE PEOPLE WHO LIVE IN IT? OF THOSE WHO LIVE NEAR IT?
>
> THE PURPOSE OF THE COSTS OF SPRAWL IS TO HELP THE MAYOR, THE CITY MANAGER, THE PLANNING BOARD, AND OTHER CONCERNED LOCAL OFFICIALS AND CITIZENS ANSWER SUCH QUESTIONS. THERE HAS BEEN NO RECENT EFFORT TO ASSESS ALL THE ECONOMIC COSTS ASSOCIATED WITH DIFFERENT TYPES OF DEVELOPMENT; NOR UNTIL NOW HAS THERE BEEN A DOCUMENT THAT ATTEMPTED TO INTEGRATE THE VARIOUS ECONOMIC, ENVIRONMENTAL, NATURAL RESOURCE, AND SOCIAL COSTS OF THESE DEVELOPMENTS."

THE COSTS OF SPRAWL IS DESIGNED TO HELP FILL THE INFORMATION VOID THAT HAS MADE DECISIONMAKING SO DIFFICULT. THE STUDY ATTEMPTS TO SUMMARIZE WHAT IS KNOWN ABOUT THE DIFFERENT COSTS AS THEY APPLY TO DIFFERENT NEIGHBORHOOD TYPES AND TO DIFFERENT COMMUNITY DEVELOPMENT PATTERNS, AND IT INDICATES WHETHER THE COSTS ARE INCURRED PUBLICLY OR PRIVATELY. TABLE I ON THE COVERSHEET FOR THIS SECTIONS LISTS THE TYPES OF COSTS THAT HAVE BEEN INCLUDED IN THIS STUDY. THESE ARE NOT ALL THE COSTS ASSOCIATED WITH RESIDENTIAL DEVELOPMENT, BUT THEY ARE AMONG THE MOST IMPORTANT ONES. THE COSTS OF SPRAWL SHOULD GIVE THE LOCAL DECISIONMAKER A STRONG START IN DEALING WITH MANY OF THE VERY DIFFICULT DECISIONS THAT HE HAS TO FACE.

THE COSTS OF SPRAWL STUDY PROVIDES US WITH AN ANALYSIS OF PROTOTYPE DEVELOPMENT PATTERNS, NOT OF ACTUAL DEVELOPMENTS, ALTHOUGH MANY OF THE DATA WERE OBTAINED FROM EMPIRICAL STUDIES UNDERTAKEN BY OTHERS. HERE THE APPROACH WAS TO ASSUME TYPICAL SITE CONDITIONS AND AN ABSENCE OF ANY EXISTING INFRASTRUCTURE (ROADS, SEWERS, ETC.) AT THE SITE AND THEN, USING STANDARD UNIT COST FIGURES, TO ESTIMATE THE COSTS OF BUILDING ALTERNATIVE TYPES OF DEVELOPMENT. TURN TO GUIDE SHEET # 21. (PAUSE 3 SECONDS)

THE VARIOUS COSTS WERE FIRST ESTIMATED FOR DIFFERENT NEIGHBORHOOD TYPES, EACH NEIGHBORHOOD BEING COMPOSED OF 1,000 DWELLING UNITS OF ONE OF THE FOLLOWING HOUSING

TYPES: AS WE LIST THE NIGHBORHOOD TYPES, LOCATE THEM ON GUIDE SHEET # 21.

- SINGLE FAMILY HOMES, CONVENTIONALLY LOCATED (PAUSE)
- SINGLE FAMILY HOMES, CLUSTERED (PAUSE)
- TOWNHOUSES (PAUSE)
- WALKUP APARTMENTS (TWO STORIES) (PAUSE)
- HIGH RISE APARTMENTS (SIX STORIES) (PAUSE)

IT IS IMPORTANT TO FAMILIARIZE YOURSELF WITH THE DEVELOPMENT TYPES IN THE STUDY. TURN THE TAPE RECORDER OFF WHILE YOU STUDY GUIDE SHEET # 21. (PAUSE 3 SECONDS)

SINCE THE STUDY COMPARES THE COST AND COMMUNITY IMPACT OF PROTOTYPE DEVELOPMENT IT IS NECESSARY TO CONSIDER THE BASIC CONSTRUCTION ASSUMPTIONS FOR EACH HOUSING PATTERN. A SUMMARY OF ASSUMPTIONS IS REPRODUCED ON GUIDE SHEET # 22.

BECAUSE THE GUIDESHEETS CAN BE COMPLEX IN THIS STUDY, WE SUGGEST YOU STOP THE RECORDER WHENEVER YOU NEED MORE TIME TO STUDY A GUIDE SHEET. FROM HERE ON IN, THE DECISION TO STOP THE RECORDER FOR GUIDE SHEET ANALYSIS WILL BE ENTIRELY UP TO YOU.

GUIDE SHEET # 23 COMPARES THE LAND BUDGET FOR THE CONSTRUCTION OF 1000 LIVING UNITS OF EACH HOUSING TYPE. NOTE THAT EACH HOUSING PATTERN HAS LAND ALLOTTED TO OPEN SPACE, SCHOOLS, PUBLIC FACILITIES, AND TRANSPORTATION IN ADDITION TO THE RESIDENTIAL LAND AREA. THE COSTS OF ALTERNATIVE NEIGHBORHOOD PROTOTYPES ARE ANALYZED IN GUIDE SHEETS 24 - 28. COST COMPARISONS HAVE BEEN COMPLETED FOR THE CAPITAL AND OPERATING COSTS FOR RESIDENTIAL DWELLING UNITS, OPEN SPACE AND RECREATION, SCHOOLS, TRANSPORTATION, STREETS AND ROADS, AND UTILITIES. THE ITEMS MENTIONED HERE ARE THOSE MOST LIKELY TO BE DIRECTLY OR INDIRECTLY AFFECTED BY THE CONSTRUCTION OF NEW HOUSING UNITS. TAKE THE TIME TO COMPARE CAPITAL AND OPERATING COSTS FOR EACH OF THE ALTERNATIVE DEVELOPMENT TYPES. (PAUSE)

THE PRIMARY VALUE OF THE STUDY DOES NOT LIE IN THE ABSOLUTE COST AND EFFECT ESTIMATES. THE GENERAL APPROACH AND SPECIFIC METHODOLOGIES ARE IMPORTANT. ALSO, THE APPROXIMATE MAGNITUDES AND RELATIVE COMPARISONS OF BOTH COSTS AND ADVERSE EFFECTS ARE MAJOR CONTRIBUTIONS OF THIS STUDY. OVERALL, COST ESTIMATES ARE BELIEVED TO BE ACCURATE WITHIN 10 PERCENT OF EITHER SIDE OF THE NUMBERS SHOWN FOR DIRECT COSTS. WHERE SUFFICIENTLY RELIABLE UNIT COST ESTIMATES WERE WIDELY AVAILABLE (AS FOR SCHOOLS, WATER, SEWERAGE, STORM DRAINAGE AND MOST PUBLIC FACILITIES AND SERVICES), THE ONLY INTERPOLATION NECESSARY WAS TO SHOW COST DIFFERENCES AMONG HOUSING TYPES AND DEVELOPMENT PATTERNS. THESE DIFFERENCES OFTEN ARE NOT DOCUMENTED IN THE LITERATURE; THUS, VARIATION IN COST ESTIMATES AMONG THE PROTOTYPES ARE BASED ON THE REASONABLE JUDGMENTS MADE BY THE RESEARCH STAFF, BASED ON THEIR EXPERIENCE AND KNOWLEDGE OF DEVELOPMENT COSTS. FOR OTHER COST CATEGORIES (ESPECIALLY RESIDENTIAL AND OPEN SPACE/RECREATION), COST DIFFERENCES AMONG ALTERNATIVE DEVELOPMENT PATTERNS ARE WELL DOCUMENTED, BUT NEEDED ADJUSTMENT TO MEET THE SPECIFIC CHARACTERISTICS OF THE PROTOTYPICAL NEIGHBORHOODS AND COMMUNITIES USED IN THIS STUDY.

AN IMPORTANT CONSIDERATION FOR LOCAL DECISION MAKERS, BEYOND THE TOTAL COST OF EACH ITEM, IS THE INCIDENCE OF COSTS. THAT IS, WILL THE CAPITAL OR OPERATING COST BE PAID BY THE PRIVATE HOMEOWNER OR THE LOCAL GOVERNMENT. THE TWO CHARTS ON GUIDE SHEET # 29 GRAPHICALLY PRESENT THE RESULT OF SUCH AN ANALYSIS. THE BAR ON THE LEFT SIDE FOR EACH HOUSING TYPE INDICATES WHERE THE MONEY WILL BE SPENT I.E., FOR RESIDENTIAL, UTILITIES, TRANSPORTATION OR SCHOOLS AND OPEN SPACE. THE RIGHT HAND BAR FOR EACH HOUSING TYPE INDICATES WHO WILL PAY THAT COST - GOVERNMENT OR PRIVATE HOMEOWNER.

THE DATA TO SUPPORT THE TWO FIGURES ON GUIDE SHEET # 29 IS LOCATED ON GUIDESHEETS # 30 AND # 31. REVIEW AND COMPARE THE ECONOMIC COSTS ASSOCIATED WITH THE SIX NEIGHBORHOOD TYPES. (PAUSE)

IN ADDITION TO ECONOMIC COSTS, ENVIRONMENTAL AND PERSONAL COSTS WERE ALSO EVALUATED IN THE COSTS OF SPRAWL STUDY. ON GUIDE SHEETS # 32 - # 34, AIR POLLUTION, WATER POLLUTION, EROSION, AND NOISE POLLUTION COSTS ARE EVALUATED FOR EACH OF THE NEIGHBORHOOD TYPES. THE COMPARISON OF AIR POLLUTION PRODUCED BY THE SIX PROTOTYPE NEIGHBORHOODS IS PRESENTED ON GUIDE SHEET # 32. AIR POLLUTION HAS TWO MAJOR SOURCES: AUTOMOBILES AND RESIDENTIAL HEATING. FOR THE PURPOSES OF THE STUDY IT WAS ASSUMED THAT AUTOMOTIVE AIR POLLUTION WOULD BE THE SAME FOR ALL NEIGHBORHOOD TYPES. THE DIFFERENCES IN AIR POLLUTION SHOWN ON THE GUIDESHEET REFLECT ONLY DIFFERENCES THAT RELATE TO THE HOUSING TYPE. (PAUSE)

EROSION AND SEDIMENTATION ARE INTERRELATED PROBLEMS, PARTICULARLY AS PART OF THE DEVELOPMENT PROCESS IN SUBURBAN FRINGE AREAS. A MEASURE OF EROSION IS SEDIMENTATION IN STREAMS AND LAKES.

ON GUIDE SHEET # 33, WATER POLLUTION IS MEASURED FOR THE PROTOTYPES IN TERMS OF SEDIMENT FROM EROSION AND POLLUTANTS FROM STORM WATER RUN-OFF. POLLUTION FROM OFF SITE SOURCES ARE NOT CONSIDERED. THE DIFFERENCES IN SEDIMENT VOLUME REFLECT THE VARIATION IN THE ASSUMED LAND BUDGET. THE SAME IS TRUE FOR OTHER WATER POLLUTANTS.

FINALLY, NOISE AS A CRITICAL FACTOR IN EVALUATING ENVIRONMENTAL EFFECTS OF ALTERNATIVE DEVELOPMENT TYPES IS PRESENTED ON GUIDE SHEET # 34. THE LIKELIHOOD OF NOISE NUISANCE WITHIN A RESIDENTIAL DEVELOPMENT FROM OUTDOOR ACTIVITY AND FROM ATTATCHED DWELLING UNITS IS CONSIDERED AT THE NEIGHBORHOOD LEVEL BECAUSE IT IS PRIMARILY A FUNCTION OF DENSITY AND HOUSING TYPE. REVIEW THE COMPARISON ON GUIDE SHEET # 34. (PAUSE)

THE NEIGHBORHOOD ANALYSIS CONSIDERS TWO TYPES OF INDIRECT PERSONAL EFFECTS OF DEVELOPMENT: (1) DISCRETIONARY TIME - TIME ALLOCATED TO HOUSEHOLD CHORES AND LEISURE AND (2) PSYCHIC COSTS - EFFECTS OF HOUSING TYPE ON PERSONAL PERCEPTIONS OF SECURITY, STATUS, PRIVACY, COMFORT, ETC. THESE PERSONAL EFFECTS ARE MOST LIKELY TO BE ASSOCIATED WITH NEIGHBORHOOD AND DWELLING UNIT CHARACTERISTICS.

ON GUIDE SHEET # 35, THE AMOUNT OF TIME SPENT ON LEISURE OR HOUSEHOLD CHORES WAS

CALCULATED BY SUBTRACTING FROM THE TOTAL TIME PER WEEK THOSE USES OF TIME WHICH WERE ASSUMED NOT TO VARY AMONG HOUSING TYPES--NAMELY SLEEP, MEALS, PERSONAL USE, TRAVEL AND, INTHE CASE OF THE HEAD OF THE HOUSEHOLD OR FOR EMPLOYED SPOUSES, WORK -- AND THEN ALLOCATING THE BALANCE BETWEEEN LEISURE AND HOUSEHOLD USES ACCORDING TO HOUSING TYPE AND POSITION IN THE FAMILY.

ANOTHER INDIRECT COST OF DEVELOPMENT THAT HAS BEEN GIVEN LITTLE ATTENTION IS THE PSYCHIC COST, OR THE MENTAL AND EMOTIONAL ATTITUDES OF INDIVIDUALS THAT ARE BOTH AFFECTED BY AND AFFECT DEVELOPMENT. ATTITUDES AFFECT DEVELOPMENT THROUGH AN EXPRESSION OF CONSUMER PREFERENCES -- SO THAT HOUSING OR COMMUNITY CHOICES THAT ARE AVAILABLE TO INDIVIDUALS WILL BE EXPRESSED IN THE MARKETPLACE BY PURCHASE OR NON-PURCHASE DECISIONS. ATTITUDES ARE AFFECTED BY DEVELOPMENT IN THAT INDIVIDUALS RESPOND IN DIFFERENT WAYS TO STRUCTURAL OR SITE FEATURES. PSYCHIC COSTS ARE SUMMARIZED ON GUIDE SHEET # 36.

IN THE ACCOMPANYING PAMPHLET, THE COSTS OF SPRAWL - AN EXECUTIVE SUMMARY, A SIMILAR ANALYSIS HAS BEEN COMPLETED FOR VARIOUS COMMUNITY DEVELOPMENT PATTERNS. THE SUMMARY DISCUSSES THE ANALYSIS FOR DIFFERING COMMUNITY DEVELOPMENTS - LOW DENSITY SPRAWL, COMBINATION MIX AND HIGH DENSITY PLANNED IN A PARALLEL MANNER TO THE NEIGHBORHOOD ANALYSIS WE JUST DISCUSSED. IF YOU ARE INTERESTED, READ THE COSTS OF SPRAWL PAMPHLET. (PAUSE)

ALSO OF INTEREST TO YOU MAY BE A SIMILAR COMPARISON OF ECONOMIC, ENVIRONMENT, AND PERSONAL COSTS OF VARIOUS COMMERCIAL DEVELOPMENT. THIS CAN BE FOUND IN THE ECONOMICS OF LAND USE A-T UNIT.

WHAT CONCLUSIONS CAN BE DRAWN FROM THE COSTS OF SPRAWL STUDIES? GUIDE SHEET # 37 REPRODUCES THE MAJOR CONCLUSIONS OF THE STUDY. IN SUMMARY, THE MAJOR CONCLUSION IS THAT , "FOR A FIXED NUMBER OF HOUSEHOLDS, "SPRAWL" IS THE MOST EXPENSIVE FORM OF RESIDENTIAL DEVELOPMENT IN TERMS OF ECONOMIC COSTS, ENVIRONMENTAL COSTS, NATURAL RESOURCE CONSUMPTION AND MANY TYPES OF PERSONAL COSTS."

THE COSTS OF SPRAWL IS NOT A FINAL DEFINITIVE STUDY. THERE ARE TOO MANY COSTS AND BENEFITS WHICH HAVE NOT BEEN INCLUDED, PARTICULARLY THOSE ASSOCIATED WITH QUESTIONS OF PERSONAL PREFERENCES AND THE REVENUES GENERATED BY DIFFERENT DEVELOPMENT TYPES. BUT THE ANALYSIS DOES PROVIDE ANOTHER BUILDING BLOCK IN THE SYNTHESIS PROCESS. THE COST OF SPRAWL STUDY PROVIDES LOCAL OFFICIALS WITH A BETTER INFORMATION BASE ABOUT THE IMPACTS OF DIFFERENT DEVELOPMENT PATTERNS, ALLOWING THEM TO MAKE BETTER INFORMED DECISIONS ABOUT THE FUTURE FORM OF THEIR COMMUNITIES.

THANK YOU FOR JOINING US FOR THE SYNTHESIS UNITS. IT HAS BEEN A PLEASURE TO HAVE YOU WITH US. STOP THE RECORDER AND READ GUIDE SHEET # 37.

Welcome to the Land Use Decision Making Unit on Geosystems. This unit is designed to involve you in evaluating the role of geosystems in the land use decision making process.

Geosystems are considered to be the systems which include the soils and geology of an area. The cover to the guide sheets for this unit has a graphic illustration of a cross section of the geosystem. The terms in the right hand margin are labels for various components of the geosystem. Stop the recorder for a few minutes and study the illustration. (Pause)

G.S. # 1

In an effort to make you become actively involved in this unit, we are assigning you a role which we wish to have you play during the first phase of this learning experience. For purposes of this unit, you are a builder or developer. We are giving you a parcel of ground to develop. A sketch of the site may be found on guide sheet # 1. Take a few minutes to determine what you will build on this site. Then, make a list of buildability factors which you feel should be considered before you begin construction. Stop the recorder, while you carry out this activity. (Pause)

Welcome back! What did you decide to build? Did you envision your building project as drawing large numbers of people to it? Did you consider access to your building or buildings? Did you consider parking needs? Did you give any thought to what the land would look like during or after construction? Did you consider the availability of water on the site? Did you consider sewage disposal factors? The factors you consider will reflect both the needs of your construction project, and the nature of the land on which you build.

Of course, the more information we have on a given site, the better we can plan for development. In the past, some buildings constructed were without much regard for the particular site that they were built upon. The statement has been too frequently made, that it makes little difference whether we build on one parcel of land or another. Land is land!

Right!' (voice change) Wrong!!! Let's take a look at a couple of slides which illustrate some potential problems related to site selection. After we complete this short survey, we will return to study some of these topics in more detail.

slide # 1

In the first slide, you can see a small post holding up the structure of a house. No, this is not a new way to build houses; something went wrong here. The ground is subsiding, and the house must be supported in some way to keep it level and help prevent it from cracking along the walls and ceiling.

The problem here relates to the ability of the soil to bear the weight of the building. If the particles that make up the soil give way easily, slippage can occur and result in cracks in the walls and ceilings of your building. Such instability can be disasterous for your building or house. If the builders of this house knew ahead of time that they would be constructing a building on a soil with this characteristic, special engineering techniques could have been utilized to compensate for possible soil slippage. Or, they might have decided to build on another site if the cost of the engineering solution was too high.

Slide #2 shows a basement containing standing water. (Pause) The water in the basement is not the result of a recent rainfall. In this case, the water is seeping up from under the building. Something is wrong here. Nobody wants a wet basement and the builder didn't expect this to happen to his group of building lots. slide # 2

Any potential builder should determine the depth of the soil above the water table. The water table reflects the ground water level or the accumulation of water above a slowly permeable soil layer. Problems are created when foundations and basements are placed at or below the level of the water table

In some areas, the water table is very close to the surface of the land. To avoid basement flooding in these areas, special construction techniques may be needed. Builders frequently attempt to deal with this kind of situation by filling or draining the areas. Both processes add to the costs of construction.

On guide sheet # 2 there is a diagram which shows the relationship of groundwater to the water table. Turn off the recorder and take a few minutes to study the diagram on guide sheet # 2. G.S. #2

The third slide shows a condominium complex that has lost a large portion of its front yard. The topsoil is being washed away and the whole scene looks disasterous. Would you be attracted to this condominium? slide #3

Land differs from area to area. There are smooth, nearly level areas, steep rugged areas, and areas of gently sloping or rolling hills. In the development process areas that are not level generally require special construction considerations, special landscaping and grading. These factors add to the costs of construction.

If the land is sloping then you must also consider the effects that rain water and runoff will have on your site. As water moves over the land surface it may move fast enough to carry away some soil. This process is called soil erosion. Water moving downhill may collect temporarily at the bottom of the slope. If you intend to build at the bottom of a hill, you may find yourself in a ponded area after a good size rainfall. After the water is finally gone, you will be left with the sediment which eroded off the hillside.

The type of soil you build upon may or may not be stable when laid bare for a construction site. Look at slide # 4. (Pause) Some soils such as those in slide # 4 will erode very quickly if the vegetation is removed. Other soils will not support vegetation. Thus trying to stabilize a cut bank with vegetative cover is difficult. The cut bank is likely to erode. This means costly addition of topsoil to the sites. The soil that has been eroded must go somewhere, either onto someone else's lawn, or into nearby waterways causing the death of plant and animal life and loss of water quality. slide #4

There are still other soils and geology factors which we should consider when planning the use of a land parcel. Just as soil characteristics vary, so does soil thickness. Some areas have very shallow soil, others have deeper soil layers. When construction begins, the builder may quickly discover he is excavating hard rock. This is a costly discovery, for it means blasting the rock if construction is to continue. This rock, called bedrock, underlies all soil. Knowledge of the depth of the soil above bedrock before construction begins can avoid many construction difficulties.

Another, buildability consideration which closely involves geosystem, is the disposal of sanitary wastes. If your building or house is not going to be serviced by sewers, you will need an on-site septic system. If you are not familiar with what an on-site septic system is and how it works, stop the recorder and study guide sheet # 3. G.S. # 3

The soil characteristics and the geology of a site effect the functioning of an on-site septic system. If the land is not level, and you have planned to use a septic tank and leaching field you may find your leaching field does not work quite the way you intended. The leachate may be puddling on the surface instead of filtering down through the soil. Special consideration may be needed for the design and construction of a leaching field on steep areas.

Because of the size of the particles they are made of, some soils may allow water to move through them very freely. Such soils drain quickly. If water can move through the soil quickly, so can the effluent from an on-site septic disposal system. The type of soil you build on may affect how well the effluent is absorbed into the leaching field and how well it may be filtered through the soil. Assuming proper design and installations this means the soil characteristics are a major determinant of the success or failure of on-site septic systems.

Closely related to soil type, is degree of water saturation in the soil. A septic field will not function if the soil is saturated with water. The effluent will not be able to be absorbed down through the soil and this will not be properly filtered. With heavy seasonal rains, the water table often moves closer to the land surface. When this occurs; the effluent or leachate will be carried up through the soil and can come through to the surface. This is not only an unpleasant situation but it is also unhealthy. Such areas are not suitable for building upon unless considerable modification of the site is made.

We must also give the depth to bedrock consideration for similar reasons. Being an impermeable substance, bedrock does not allow the downward flow of water. Even if we were to find a depression of "pocket of soil" in bedrock in which to build a house, there may not be enough soil present for an on-site septic disposal system. Health codes stipulate that there must be at least 4 feet of vertical distance between the bottom of a septic field and the bedrock for filtration of the effluent. If such a site is not serviced by sewers and needs an on-site system - there will be real problems if the bedrock is close to the soil surface.

Finally, knowledge about the land will allow us to extract resources beneath the land surface. Slide # 5 shows a picture of sand and gravel mounds at a quarry. In Connecticut, we extract sand and gravel as well as trap rock for building and construction uses. They are valuable resources. Knowledge of the geology of an area, will help locate these valuable resources and will permit them to be removed before they become tied up underneath residential, commercial or industrial develop- slide #5 ments.

We have discussed but a few development considerations that must be made with regard to soil composition and geology. There are many more which shall be discussed in detail further along in this unit. We have also presented a minimum of examples on how land use may be affected by variations in land, that is, variations in its shape and variations in its composition. Let's proceed one by one to analyze in detail how these differences in the land affect the way in which we ultimately make use of the land. Let's find out how information about the land may be obtained and how this information can be utilized to our greatest advantage in land use decision making!

Guide sheet # 4 lists the objectives for the geosystem unit. They will give you an idea of the knowledge and skills you will obtain while you are working with the unit. Turn off the recorder while you read the objectives (Pause). G.S. #4

First return to our discussion of the shape of the land. By the shape of the land, we mean the elevations, depressions, and level areas. This is the land's topography. It is the surface character of the land.

In Connecticut, our land surface has undergone many changes because of a geologic event called glaciation. Approximately 15,000 years ago an ice mass called a glacier, covered and eventually moved across this area. The pressure exerted by the glacier, the force of abrasion from its movement and the force of the meltwaters all served to carve out and construct a great deal of Connecticut's landform as we see it today. Guide sheet #5 has a diagram of the land features of Connecticut. G.S. #5 As we proceed with our discussion, study the illustration and definitions on guide sheet # 5.

In the eastern and western areas of our state we have very resistant rock forms that stood up to a great deal of the glaciers power. These rock remains form the Connecticut highlands.

In other parts of Connecticut the glacier pushed down great loads of rock debris called till. As the glacier moved, it carved out its own deposits to form thin hills, parallel to the north-south movement of the glacier. These thin hills are called drumlins.

In other areas of Connecticut we find stepped but flat-topped land forms. These are usually found along valley sides and are called terraces. As the glacier melted, debris and sediments were carried down by water along the side of the glacier and built up the land on the valley side.

In southern Connecticut, we have broad level areas. These are outwash plains where the meltwaters of the glacier spread rock debris in broad sheets beyond the glacial ice.

There is one other topographic feature that we should discuss, the floodplain. Floodplains are not the result of glaciation, they are quite common not only in our state but in all areas that have sizeable waterways. The floodplain is the lowland that borders a river or stream. It is formed by nature as a drainage channel for flood flows resulting from heavy snowmelt or rainfall. The floodplain is usually dry but is subject to periodic flooding. Connecticut is laced with river systems, and each has its own floodplain. (Pause)

How can we put together the information about all the various land features? What is it that each exhibits even though they appear very different from one another? We need a common factor!

The common factor is Slope. Slope is a ratio that tells us how quickly a land area rises in relation to the distance it takes to reach a given elevation. This relationship is diagrammed on guide sheet # 6A. On guide sheet # 6 part B there are two diagrams to illustrate different G.S. #6 slopes.' Turn off the tape recorder and study guide sheet # 6 diagrams A & B before we go on. (Pause) G.S. #6B

The slope of the land is a topographic characteristic. It affects land use in a variety of ways depending on its steepness. It directly affects the cost of construction and the degree of environmental impact that construction on a given site will have. If you should decide to construct a building, a road, or to install services, on a slope, you will need to make the site relatively level. Look at guide sheet # 6 part C as we describe this leveling process. (Pause) G.S. #6C

Material cut from the uphill slope is used to build up the downhill slope. The builder now has a level area for construction. However, there are two places that most likely will need retaining walls or vegetational cover. If the retaining walls are not properly planted, the uphill bank could erode into the backyard or the downhill bank could slip or erode and carry soil from the front yard down the hill.

If you have decided to build on a sloping land area what other factors should you consider? (Pause) Are you building in an area not yet developed? For example a nice high area out in the country as in slide # 6? The view must be great, the peace and quiet are a real pleasure. However slide #6 you still need services, utilities and sewage disposal. There are no sewers out here, that means an on-site septic system. But a septic field requires a relatively level area. A special system design is needed for sloping areas.

On a downhill slope the effluent under the force of gravity spreads outward in many directions--all downslope. This means there is little control over the effluent. On many hillsides, underlying rock or dense soils do not provide adequate downward penetration of septic system effluent. The effluent may even break out onto the surface further downhill.

Look at guide sheet # 6 part D. Here you see a diagram of a septic tank sewage disposal G.S.#6D system designed for a sloping land. The tile lines are laid on the contour of the land rather than straight out and slightly downward from the tank.

In many of the landforms we discussed earlier, slope is not steep. Thus construction techniques and special designs can well overcome the limitations slope may cause. In Connecticut however, there are many areas with steep slopes. Some of these areas have bedrock layers that are very close to the surface. There may also be areas with outcroppings where the rock appears above the soil surface. The slide in your viewer shows a home built in a rock outcrop area. In the foreground you can see the rock outcrops. Excavation costs are increased in such areas, there is little soil to adequately filter the septic system wastes and accessibility is very difficult.

What about areas of little to no slope? These are perhaps easy to build upon but again consideration must be given to other geosystem factors. For example, we discussed the level areas bordering a river, the floodplain. These areas are accessible, level, even very fertile for planting and landscaping. But the one thing that made this area so level and so fertile also makes it hazardous to build here- the RIVER. The floodplain is that area that takes on the extra waters from heavy rains or snowmelt. Construction along a floodplain, especially in the form of bridges and roadways provide obstructions during a flood. These only serve to raise the level of the flood waters above their natural height. Higher flood-waters means greater damage to nearby buildings. Building in floodplains is a gamble. Suitable land uses for the flood plain might be agriculture, open space, forestry, water related industry, marinas, or water using industry.

It is obvious that there are many geosystem factors to consider before and during construction, but how can we gather information about the land? How can we determine if a site has a steep slope, gentle slope or is nearly level? How do we know that a parcel of land is in a floodplain without actually visiting the site? One method is to use a topographic map.

Turn to guide sheet # 7, lift the tracing paper and expose the topographic map. This is a reproduction of a portion of the Wallingford Quadrangle topographic map. The actual map is used in the unit on maps and map reading. G.S. #7

A topographic map presents landforms in terms of their slope and contour. The lines on the maps that do not define roads are contour lines. Each line represents a particular elevation and follows the contour of land at that elevation. Each line is ten feet higher or lower than the adjacent line.

Heavy contour lines are used to indicate 50 foot intervals . . on your map, the lines at 200, 250 and 300 etc. are typical of the 50 foot interval lines.

The closer the lines are to each other, the steeper the slope. When the contour lines are close together, the land is rising or falling in elevation over a short distance. Conversely, the farther apart the contour lines are, the flatter the land area is.

On the topographic map, on guide sheet # 7 identify the areas with the steepest slope and the flattest area on the map. (Pause) Remember, with steep slopes, the contour lines are close together. On relatively level areas, the contour lines are far apart. There is more than one steep or flat area on guide sheet # 7. Take your time in locating the steepest and flattest areas. Turn off the tape recorder while you carry out this activity. (Pause)

Now that you have done your best, there is a tracing paper overlay on the previous page which can be laid over the map on guide sheet # 7. The steepest area and flattest area are marked on the overlay. (Pause) How did you make out? Turn off the recorder if you want more time to study the maps before going on to the next part of the unit.

After completing the previous exercise, you should obtain a copy of the topographic map for your town. Find your neighborhood and see how it is represented in contour and elevation on the map.

Let us move on and discuss the composition of the land. How does the composition of land vary and how may we obtain information about the composition of the land?

First, let's take a look at how soil is formed. The different minerals in a rock do not expand and contract alike. Therefore, when a rock surface is subjected to sudden changes in temperature, the rock tends to crack and flake. When water works its way into these cracks and freezes, it expands and breaks the rock apart. Coarse grained rocks will develop larger cracks and breakdown faster than fine grained rocks.

Once water has begun to break the rocks into smaller fragments, the water is able to come into contact with more surface area of the rock. It is then able to react chemically with the minerals present in the rock. The soluble compounds in the rock may be dissolved and transported down through the soil into the groundwater, or they may move down a short distance and form a distinct layer in the soil.

The presence of plant and animal life in the soil adds to the organic content of the soil. In addition, burrowing animals and plant roots loosen up the soil and create air spaces. When these organisms die and decompose, they replenish the soil with a wide range of compounds which form a nutrient pool for future plant growth.

Another factor at work in soil formation is slope. Slope affects the speed of water flow able to pass over the land surface. The steeper the slope, the faster the water runs and the less able it is to penetrate within the soil itself. Erosion may occur and the soil may be constantly swept away preventing some areas from ever developing a stable soil cover.

Obviously, time is a major factor in the process of soil formation. It is time which provides for enough physical and chemical reactions to occur to develop a distinct soil layer. It is time that allows for enough rain to fall to affect the water content of the soil and possibly erode the land. It is time which allows for the parent rock material to undergo all these changes and develop a soil layer which is mature.

As the many processes and changes take place, soil with a distinct appearance is formed. The soil is layered showing the differing areas where certain chemical reactions occured and where the end products of these reactions have been deposited. These distinct layers are called horizons. A vertical view of the soil exposing all the layers or horizons is called a "soil profile".

Take a look at slide # 7. In slide # 7 you see a soil profile. In this profile, two distinctive slide
soil layers can be distinguished. The upper layer horizon A is several inches thick and is much #17
darker in appearance than the lower level or horizon B. (Pause) Now look at guide sheet # 8. G.S. #8
On guide sheet # 8, you see a graphic representation of an idealized soil profile with selected information about the soil horizons. Turn off the tape recorder and read guide sheet # 8. (Pause)

There are some generalizations that can be made about soil color and texture from the soil profile
without going through a detailed analysis. On guide sheet # 9 there are generalizations about G.S. #9
soil based upon its color and texture. Stop the recorder and read guide sheet # 9a. (Pause) Usually subsurface soil colors are lighter than surface soils. Mottling, or the "patchy-colored" effect of some soils is caused by alternating layers of soil with good and poor aeration. This usually happens when the amount of ground water rises with seasonal rains.

You may also note that soils differ in texture. Texture refers to the coarseness or fineness of soil, and is determined by the size of the mineral grains that make up the soil. There are basically three categories of soil particles that determine the soil texture. These are listed on guide sheet # 9 part B. These three categories describe soils by their grain size. Stop the recorder while you study the categories outlined on guide sheet # 9B. (Pause) G.S. 9B

It is important to emphasize that soils are rarely pure silt, clay, or sand. Usually, a soil is a mixture of soils from the three basic categories. However, one soil type may predominate.

The mixing of soil types allows for great variety in the appearance and characteristics of soils. Soil scientists have done a great deal of work evaluating and categorizing soils utilizing information about soil variations. Soils that have profiles very similar in thickness and arrangement of the major horizons and other important characteristics are called a "soil series". Each soil series is named for a town or other geographic feature near the place where the soil was first observed and mapped.

For instance, soils have been named Charlton, Holyoke, Paxton, Ninigret, Woodbridge, etc. The soil is named after the town in which it is first located. After the first identification, every time the soil is found again, it maintains its original name regardless of the locale in which it occurs.

Soil scientists working for the Soil Conservation Service (SCS) make a soil survey to learn what kind of soils are in a given location. As the soil scientists walk over the area, they observe the steepness of the land, shape of the land, kinds of rocks and any other characteristics which will aid in their understanding of the soil and its relation to the environment. They dig holes to expose the soil profile. Then they classify and name the soil according to a standardized procedure.

Soils can differ in texture, slope and stoniness among other characteristics. On the basis of such differences, soil scientists further differentiate among the soils within a soil series. The classification of soils by textures slope, and stoniness produces categories called "soil phases". On the top of guide sheet # 10 you will find definitions and a table to help clarify the nomenclature. Lets use the Ninigret soil series as an example. Remember that the name Ninigret designates a soil series and is named after the town in which it was found. Once the texture and slope characteristics are added to the name it is called a soil phase. In our example, the soil series is Ninigret; Ninigret, fine sandy loam, with 0-3% slope is a soil phase and also the soil unit that is represented on a map. G.S. 10

On slide # 8, there is a sample soil survey map. The soil map is usually drawn on an aerial photograph on which woodlands, buildings, field borders, trees and other detail can be distinguished. These details aid the soil scientist in drawing accurate boundaries for the mapping units. As you probably have noticed already, there is not room in each mapping unit to write in a full soil phase name such as Ninigret, fine sandy loam, 0 to 3% slope. For mapping purposes, soil scientists have developed a set of abbreviations, the shorthand system for soil symbols is summarized in section C of guide sheet # 10. On published soil surveys, Ninigret fine sandy loam, 0 - 3% slope would be abbreviated NnA. The capital letter, N, represents the soil series. Together with the little n, Nn, slide 8 is the soil type. The capital A at the end of the symbol, represents a 0-3% slope.

The first capital letter in each symbol is the initial of the soil name. The second capital letter A, B, C, D, or E, if used shows the slope. The slope symbol represents the average slope in a soil phase. Some soil symbols which contain no slope letter are for nearly level soils or land types. A final number in the symbol shows that the soil is eroded. If no erosion is observed, no symbol is indicated.

Not all the soil maps for the state of Connecticut have been published. On working maps, soil scientists code soil series temporarily with numbers. The numbers are translated to letters when the soil survey is published. In the far right hand column, the number type code is represented. For our purposes in this unit, we will use the alphabetical symbol and published surveys.

Let us check your ability to decode the symbols on a soil surveys.. On part D of guide sheet # 10 there is a sample soil symbol legend as well as a set of symbols for you to interpret. Turn off your recorder and do these exercises.

Now that you have had an elementary exposure to interpreting a soil survey, obtain a copy of your county's soil survey report and study the soil types and conditions of slope, rockiness and erosion in your community. If you get the soil survey report for your community, you will be able to see how a soil survey appears in its entirety. You will also be able to see the very specific types of information given in these surveys for special land uses such as agriculture. In many soil surveys, for example, soil scientists have even estimated the average per acre yield of principal crops such as silage corn or alfalfa hay for a given soil series.

You might also find it very interesting to look up the soil type you live upon. Check out its suitabilities and limitations just as we will be doing in the following exercises.

Now that you know soils may vary considerably depending upon factors at work during their formation, what does this information mean to you? What effect will this information have upon you as you make land use decisions?

The properties soil exhibits may greatly affect usage patterns for a particular site. Each land area has a set of characteristics which we can infer from the soil type. Different soil types will differ in the degree to which their properties effect land use. Knowledge of the properties of a particular soil type may mean success or failure in your planning of a land use. The properties we are referring to are: permeability, erodibility, bearing capacity and the depth to bedrock or an impermeable layer of soil known as hardpans.

Permeability is the ability of the soil to permit the movement of air and water through the soil layers. Permeability depends not only on the size of openings and pore spaces present in soil, but also on the amount of interconnection among the openings. On guide sheet # 11 there are two G.S. #11 diagrams contrasting soils with different permeabilities. (Pause) In the first example, we see soil particles that are fairly uniform in size. This creates a great deal of space between the particles for air and water movement. The second soil type however, has small particles filling in the spaces between the larger particles. This condition restricts the movement of water and air through the soil. Permeability is an important factor in the planning of on-site septic tank sewage disposal systems. If the soil is not permeable, the septic system may back up or the effluent from the system may emerge at the soil surface as in slide # 9. In either case, a health hazard is created. If the soil is too permeable, the sewage effluent may move downward into the groundwater too rapidly to be adequately filtered and purified. This too may create a serious health problem. slide #9

To estimate the potential rate of movement of sewage effluent through soil and away from the absorption field, a percolation test is made.

Percolation tests give us a indication of the permeability of the soil. Percolation tests determine the suitability of a particular soil types for on-site sewage disposal. The standard percolation rate is 1" per 30 min for infiltration of water into the soil. This precludes the possibility of unsanitary surface conditions.

On part B of guide sheet # 11, there is a description of how a percolation test is made. Turn off the recorder and spend a few minutes familiarizing yourself with the percolation test and its relation to on-site septic systems. (Pause)

While it is important to perform a percolation test at every site as the guide sheet mentions, it is possible to obtain a first approximation of the percolation rate from the soil survey and a key of percolation rates. Turn to guide sheet # 12. G.S. #12

Scientists have divided soil phases into four classes of percolation rates: fast, probably fast, probably slow, and slow. To determine the percolation rate of a specific soil phase, scan the table to find which classification your soil phase is under. For instance, if a home site was located on a soil phase identified as GaB (pause) we would search the table to find which section GaB is located in. In this case GaB is found in the probably fast category. Look at the probably fast category and locate soil phase GaB. If a building site was on a LuA soil phase (pause) what would you expect its percolation rate to be? (5 sec pause) Correct, it would most probably have a slow percolation rate.

As we mentioned earlier, the key is only a rough guide. A percolation test must still be performed on the site! However, the key helps us in the first stage of planning. We will return later to the percolation key to help us make some land use decisions.

Permeability of the soil will also influence the amount of groundwater available. A detailed explanation of groundwater and its importance is given in the Hydrology Unit. Basically, the more permeable the soil the greater the supply of water available is the area.

Another property which we will consider is the erosion potential of different soils. When cleared of vegetation, for construction or other activities, soils which differ in texture will erode at different rates, even under similar conditions of rainfall, slope and length of slope. It is annoying and expensive for homeowners and contractors to have to buy topsoil to replace soil that has washed away from a building site.

The problem doesn't end with the construction site itself. Earlier in this unit we pointed out that eroding soil must go somewhere. Look at slide # 10. Houses in this development have lost topsoil through erosion. Look where the eroding soil is being deposited. The soil is going right into the roadway. This means costly town maintenance of the road to remove the sediment and irritation to the neighbors when their automobiles get scratched and dirtied. Now look at the next slide .

slide # 10. Since when is water brown? This waterway has been muddied from the construction sites in the background. No steps were taken to prevent erosion during construction. What kind of fish or wildlife, would you imagine could survive such conditions? It's not very pleasant is it? Think of this the next time you see a construction site with the soil exposed and the ground vegetation gone. If you check closely you will probably see gullies and rills, the signals of the ongoing process of erosion. slide 10

However, the problems of erosion on moderately steep slopes are not insurmountable. With careful planning, many slopes can be developed in an environmentally sound manner. Guide sheet # 13 outlines some principles and procedures suggested by the Soil Conservation Service to reduce erosion. The principles are effective on soils that are suited for developement. They include such practices as, leaving the soil bare for the shortest period of time, . . . reducing the velocity and controlling flow of run-off, . . . detaining runoff on the site to trap sediment, and releasing runoff safely to downstream areas. If you are interested or are confronted with erosion and sedimentation problems, we suggest you contact the Soil Conservation Service for advice or their excellent written materials. Stop the recorder, while you study guide sheet # 13. G.S. #13

Another soil characteristic of importance in land use planning is bearing capacity. Slide # 11 shows what can happen if you do not give proper attention to the soils. The bearing capacity of a soil is how much load per square foot the soil can withstand before it is deformed. This depends on the uniformity of the grain or particle size of the soil. Try to stack up marbles to form a mound. It won't work. Likewise, a soil made of uniform grains is not stable and is subject to slippage. Slippage is of special concern in soils with any significant amount of clay, or fine sand. Increase in moisture content will serve to decrease the stability of these soils. Bearing capacity estimates the plasticity of the soil. It can be considered to be an indicator of the ease of compaction of the soil. Engineers test bearing capacity by varying the moisture content of the soil sample and subjecting the soil to stress of known weights. They then determine any movement, tilting, or sinking that would indicate the soils instability. slide # 11

Unfortunately, on many construction sites, the soil suitability for bearing a heavy load is discovered only after construction has begun. If this property is tested far ahead of time it serves to minimize unnecessary construction and maintenance costs. Engineers are able to determine how wide a footing is needed to support the weight of a given structure in a specific soil phase. In some cases, the supports must go far down into the earth to gain the stability needed to support the building. Knowledge of the bearing capacity also helps to evaluate a soil for traffic flow and possible frost heaving of roads. Obviously, in slide # 12, the soil was not capable of bearing the heavy load of traffic on the roadway. In Connecticut, we are fortunate to have slide # 12 very few soils which have a low bearing capacity.

Another consideration in evaluating the soil for various land uses is the presence or absence of hardpan or fragipan. Both terms are used in Connecticut for a slowly permeable subsurface layer formed in compact glacial till. Downward movement of water is severely restricted in hardpan. Excess water from heavy rain, spring thaw or septic effluent are unable to filter through this soil layer. As a result, the water or sewage effluent will move laterally over the tope of the "pan". In slide # 12, we can see a cut bank with sewage effluent seeping out. The sewage effluent is the silver gray colored substance, seeping out of the bank several feet below the soil surface. Fragipan or hardpan may be more of a problem than a layer of bedrock since bedrock frequently has cracks through which water can move. Footing drains are generally necessary to prevent the seepage of water into basements in areas with fragipan or hardpan soil layers.

There are two other factors which are necessary for us to consider in land use decision making which relate not to the composition of the soil as much as to the depth of the soil. These are the depth of the soil over bedrock and the depth of soil above the water-table.

First we shall consider the importance of depth of the soil to bedrock. Bedrock lying close to the surface has its advantages and disadvantages. Some structures require the stability that bedrock provides. In fact many tall buildings have footings that are based on bedrock. If a soil does not have good bearing capacity, a builder may be forced to go down to bedrock for structural stability.

Architects often utilize ridges and rocky slopes for the dramatic effect bedrock outcrops create. In general, however, bedrock close to the surface creates problems. Excavation for basements and utilities may require blasting. On steeper slopes, cutting and filling for roads and building sites may encounter bedrock. This again hinders construction both in terms of time and cost.

Areas where bedrock is covered by a shadow soil layer can present problems for on-site septic tank disposal systems. Refer to guide sheet # 14. (Pause) Septic tank systems rely on filtration by soil to purify their effluent. This filtration process is shown in the diagram at the top of guide sheet # 14. Diagram B on the same page shows why sewage effluent would not be adequately filtered if the depth of soil above bedrock were insufficient. G.S #14 (Pause) In Connecticut, the public health code requires 4 feet of material having an acceptable percolation rate between the bottom of the leaching trenches and the bedrock ledge.

In diagram C we see a slanting bedrock surface. The effluent, inadequately filtered may flow downhill along the bedrock surface only to emerge at the ground surface where the bedrock outcrops. This is a condition similar to that in slide # 13, where the effluent was seeping out of the bank. slide 13 Another possibility is that the effluent will flow rapidly through cracks or fissures in the bedrock. This could allow sewage effluent to infiltrate the groundwater resulting in pollution of the water supply.

Again, it is possible to obtain information about the depth to bedrock from the soil survey and an accompanying key for depth to bedrock. On Part II of guide sheet # 14, there is a key for soil G.S.#14 phases which contain bedrock within 2 feet of the surface. If the soil is not listed the depth to bedrock will probably be greater than 2 feet. For example, soil phase RK (pause) has shallow bedrock, since it is listed in the key. But soil phase WuC (pause) is not on the key, so this phase probably has bedrock greater than 2 feet below the surface.

The depth of the soil above bedrock is directly related to crop productivity of both farms and forests. Deep soils are generally able to store more moisture and nutrients for plants than shallow soils. Soil scientists have classified different soils on the basis of their agricultural productivity. The key on guide sheet # 15 lists the soil phases that have been classified as the G.S. #15 best suited for agricultural purposes. There are eight agricultural capability classes. Class I and II soils are best suited for agricultural purposes as well as many other land uses. The proposal to preserve some of Connecticut's prime agricultural land was based on the agricultural land use capability system. The Commission proposed that farms with class I, II or III soils be considered for preservation from development. If you are interested in this topic, the Uplands Unit considers the preservation of agricultural land in more detail. The important point at this moment is that land can be classified with regard to its agricultural capability based upon soil phase.

Another important soils consideration is the depth of the soil above the water table or zone of saturation of groundwater and or perched-water. Some areas have high water tables periodically during wet seasons, others have high water tables which persist throughout the year. Since the water table fluctuates seasonally due to rains and droughts, it is necessary to note their maximum height and their duration at depths which affect land use. Drainage categories are used in the classification of soils to describe the duration of the high water table during the year. Stop the tape recorder and look at guide sheet # 16 for an explanation of the drainage categories. G.S. #16
(Pause)

Drainage categories may be determined by observing plant life of the area, topography and direct observation of groundwater in test holes. Look at slide # 14. slide 14 The presence of "mottling", that is, those alternating patches of orange and grey in soil, indirectly indicates the upper level of groundwater fluctuation. Mottling is caused by chemical reactions occurring when the pore spaces of the soil are filled part of the year with air and part of the year with water. In short, air and water cause the oxidation or rusting of the metallic components such as iron which are found in soil.

Soils with a high water table present severe building limitations. Basements can be flooded seasonally and septic tank absorption fields will not function. A look at the diagram in the center of guide sheet # 16 will help demonstrate how a high water table affects septic sewage effluent. G.S. #16 The water table in this diagram is at the level of the tile field. The solid waste in these soils will become flooded with water during wet periods of the year producing an undesireable leachate. The high water table forces this leachate upward to the surface. This creates an unsanitary condition and is a health hazard. The greater consequences of this occurrence is the possible affect to the ground and surface water quality of the area. Attention must be given to drainage systems or filling if development is to take place in areas with high water tables. If you wish to develop a wetland area, you must comply with the regulations set forth in P.A. 155 (1972), The Inlands Wetland and Water Courses Act. Most development in these areas can proceed only with a permit from the local Inland Wetlands Agency or State Department of Environmental Protection. Regulations cover deposition, filling or removing material, the diversion or obstruction of water flow, and the erection of structures. Basic information on this subject is presented in the Inland Wetlands A-T unit.

We now have a wealth of information about soils and water table, but how do we know whether we are building on a suitable soil or a wet soil without lengthy and costly on site analysis?

It is again possible to use a key and soil survey map to make a first determination of depth to water table.

Guidesheet # 16C lists soil phases which have a temporary high water table within 3 feet of G.S. #16C the land surface during the rainy season. The high water table seldom persists beyond late spring.

On Guidesheet # 17 is a key for soils saturated with water within 3 feet of the surface for G.S. #17 between 2 and 12 months. The exact definitions of these soils are listed on the top of the guidesheet. (Pause) For example, soil phase Am is coded 3a which indicates a poorly drained soil. We will begin to use the keys to obtain information about sites in the next section. Before we go on, stop the recorder and study guidesheet # 16 and # 17. (Pause)

Now lets put all our information to use! On guidesheet # 18, there is a graphic representation of a soil survey map. We have deleted the aerial photograph background for this exercise, but retained the mapping units. Place the soil survey map on guidesheet # 18 in front of you. Locate G.S. #18 site # 1. (Pause) We will assume that site # 1 is a building lot that we have the opportunity to evaluate. Lets assemble information about the site together.

The best starting point is to find the soil survey symbol on the map and to decipher it based on the soil symbol legend for names of soils on the Decoding Chart for symbols on guidesheet # 10. (Pause) For site # 1, the symbol EsA can be deciphered as follows: Es represents Enfield silt loam and A represents 0-3% slope. A form has been provided on guidesheet # 19, to summarize G.S. #19 the information we are accumulating on this site. On guide sheet # 19 we can enter the slope as 0-3% and soil texture as silt loam. Since rockiness is not indicated in the symbol, we can assume the site is not rocky. The probable percolation rate can be determined from the key on guidesheet G.S. #12 #12. (Pause). We find that the symbol EsA is listed under the fast percolation rate section. The information about our site is then recorded on guidesheet # 19. Site # 1 will probably have a G.S. #14 fast percolation.

The depth to bedrock key is listed on guide sheet # 14. (Pause) The symbol EsA is not listed on the key on guide sheet # 14. This indicates that bedrock is at least 2 feet below the surface on the site. Wetness is determined by checking the keys on guidesheet # 16 and # 17. Both keys must be checked. (Pause) Soil phase EsA is not listed on either key leading to the conclusion that the watertable does not come within 3 feet of the soil surface during the year. Finally, let's check the Agricultural Land key on guidesheet # 15 (Pause) to determine if the soil is suitable for agriculture. EsA is listed as Class I which is prime agricultural land. After entering our data on Guidesheet # 19, we can begin to synthesize the information to determine our development options. The site, based on soils information appears to be an acceptable building lot. The percolation rate is acceptable for on-site septic systems, there are no bedrock problems and no problems with high water table. The only reservation is that it is prime agricultural land that possibly should be kept in food production. Even though we have made some tenative conclusions based on the data in the soil survey, we should not make a final decision until we have visited the site and completed on-site testing and evaluation to confirm our predictions. G.S. #19

It is time for you to try your skills at site analysis. Complete an analysis of site # 2 and site # 3 located on guidesheet # 18. There is room to record your analysis on the lower half of guidesheet # 19 or you may use scrap paper. Turn off the recorder while you work. (Pause)

Welcome back. I am glad you did so well on your site analysis. Soil Scientists at the Connecticut office of the Soil Conservation Service have developed a matrix that will significantly aid us in our decision making. Guide sheet # 20 contains the master matrix. (Pause). They have listed the soil properties down the left hand column and various land uses across the top. An X is placed in each box where consideration of a soil property is important in deciding whether the land use is suitable based on the soil characteristics. G.S. #20

For instance, if you were considering building a small commercial building, component No. 6 from the top of this chart, you would want information on wetness, depth of bedrock, slope, soil texture, surface stoniness, surface rockiness, and flooding. The rationale for considering each soil property is based on the discussions of each property in this unit.

The Soil Conservation Service has carried this analysis one step further. They have developed a similar matrix for each soil phase. Guidesheet # 21 is one example. Instead of simply placing an X in a box, they have rated each property in terms of degree of limitation for each use - SLIGHT, MODERATE or SEVERE. The degree of limitation indicates the severity of problems expected to be encountered for a specific use. Major hazards are listed when the soil has a Moderate or Severe rating. Also, they have provided a quantitative evaluation of each property, such as indicating on this matrix that the depth to bedrock was 5 feet plus. The explanation of the code is on guide sheet # 22. G.S. #21 G.S. #22

Let us work through the analysis of one matrix together. The sample matrixes were selected because they match the exercise on guide sheet # 19. After we work through one matrix, you can go back to compare your analysis of your sites with the analysis of the Soil Conservation Service.

Let's begin with guide sheet # 21, the Woodbridge extremely stony fine sandy loam, 3 to 8 G.S #21 percent slopes. We will examine two land uses, no. 4. Dwellings with basements and no. 10 picnic areas.

Under dwellings with basements the matrix lists two severe limitations, surface wetness and surface stoniness. In providing a rating at the bottom of the matrix, the soil scientists concluded that there were severe limitations on using this site for a home with a basement.

In comparison, the use of the site as a picnic area had only one severe limitation, stoniness, and six slight limitations. Yet in their rating of this site as a picnic area, they suggest the site had severe limitations. The rating is not a weighted average. The most limiting property dominates the rating. For instance if all properties were rated slight limitations except one property that had a moderate limitation, the overall rating would be moderate limitation.

The matrixes provide valuable insights into the influence of the geosystem on land use decisions. The Soil Conservation Service is an excellent resource, we suggest you utilize them. Most importantly, obtain a copy of the soil survey for your town and the accompanying tables and explanatory material. Now, return to the matrixes on guide sheet # 21, # 23 and # 24 to compare your analysis of the three sites from guide sheet # 18 with the work of the Soil Conservation Service. G.S. # 21,23,24 It is especially important to understand how different soil properties influence different land uses. Turn the recorder off while you work with the matrixes.

We have covered the most important aspects of soil formation, composition and properties. Now lets turn our attention to other aspects of the geosystem.

There are frequently deposits of geological material between the upper soil layer and bedrock. Guide Sheet #25 has a diagram which graphically illustrates the location of a deposit in a geological cross section. Geological deposits which occur in the few feet between the soil layer and bedrock are referred to as surficial geological deposits. These deposits of sediments or rock fragments have been carried to their present site by ancient glaciers, weathering, erosion or the activities of man. After the material was deposited, soil slowly formed to produce a covering soil layer. In many instances the presence of geological deposits will significantly influence the land use decision making process.

Information on surficial geological deposits can be obtained from a surficial geology map. Locate the surficial geology map of the Wallingford Quadrangle in your kit...open the map and stop the recorder while you make a brief study of the map format. When you have familiarized yourself with the general map layout, turn the recorder back on...(Pause)

You have probably noticed that the surficial geology map is a topographic quadrangle map with a new color code super-imposed. The surficial geology map has been designed this way so that contour lines will be present and the scale of the surficial geology will be the same as the topographic map. The contour lines, as we discussed earlier, help us determine slope on a site.

Before using any map, we should determine what year the map was produced. As you will note in the lower left hand corner, this surficial geology map is drawn on a topographic map prepared in 1954. For this reason many recent residential industrial and commercial developments are not shown on the map. Even Interstate 91 a major highway diagonally crossing the Wallingford Quadrangle is missing from the 1954 topographic map.

In any event, since the geological deposits have not changed, the map is suitable for our work in land use decision making.

The color key for the surficial geology map is in the upper right hand corner of the map. Turn the tape recorder off for a few minutes while you familiarize yourself with the color key, and the geological deposits which each color represents.

Let us begin our interpretation of the surfical geology map, with the top symbol in the key - artifical fill. Artifical fill is denoted by a dark brown color. It consists of deposits produced by man. These include highway and building fills and large accumulations of trash.

The Wilbur Cross Parkway is a prominent man-made feature that follows the Quinnipiac Valley from the center of the northern boundary of the Quadrangle to the southwest corner. The brown diagonal represents the artificiall fill necessary for the construction of the highway bed.

Stop the tape recorder and locate additional artifical fill areas. (Pause) What other evidences of man's activities do you find? Are the filled areas railroad rights of way, commercial or industrial developments or road beds? All of these uses have involved the use of fill in the Wallingford Quadrangle.

The predominant color on the surficial geology map is green. The key on the right indicates that the color green represents Till. Earlier, in the unit on guide sheet #5, we defined till as unstratified glacial drift deposited directly by the glaciers. Till consists of clay, sand, gravel and boulder intermingled in any propostion. Slide #15 (pause) shows a cut bank exposing the particles called till. Note that the till in slide #15 is composed of a mixture of particles ranging in size from clay to boulders.

Layers of till are usually several feet thick and in places may be compacted and quite dense. Till in the Wallingford Quadrangle like till in most of New England is quite stony.

As the glacier melted, its meltwaters carried rock fragments and soil that had been collected during the glacier's movement. The flowing meltwater sorted the debris by size. Close to the melting glacier, where the water flow was rapid, only the larger, heavier rock fragments were deposited. Further downstream where the flow was much slower, smaller and lighter, particles were deposited. These deposits are called ice-contact "stratified drift" because they have been deposited in layers. Each layer being relatively uniform in the particles sizes. On slide #16 there is an example of ice contact stratified drift. Notice the layer of gravel and then layers of sand. Not all stratified drift is as neatly sorted as this. By comparing slide 15 & 16 you can easily see the difference between glacial till and stratified drift. On the surficial geology map, "ice-contact stratified drift" is represented by the color pink. Stop the recorder while you locate deposits of stratified drift on this surficial geology map. Turn the recorder back on when you are ready to procede.

One other type of deposit of importance has been formed since glacial times. This material, called alluvium, has been deposited by flood waters or meandering rivers. Alluvium consists of thin layers of fine gravel, sand, silt and clay which covers valley floors and river floodplain. Alluvial deposits are indicated by bright yellow patches on the surficial geology map. If you look carefully, you will find that alluvial deposits occur on both sides of the meandering Quinnipiac River. Alluvial deposits are also found in the floodplains of several small streams in the Wallingford Quadrangle.

In the lower right hand corner of the map, you will notice several purple areas. (pause) The map key explains that purple areas represent bedrock. Dark purple indicates individual exposures of bedrock above the surface, while the lighter purple shading represents areas "with small or scattered exposures, or areas thinly covered with soil." As we have discussed earlier, bedrock on a site can mean additional expense excavating basements installing utility lines and can prohibit the use of on site septic systems. On the positive side, bedrock can provide a very suitable base for foundations.

The Surficial Geology map can also provide information on the economic geology of the region. Geologic materials such as gravel, sand or trap rock can be an important economic resource. We may wish to find out where they are located so we can excavate them and utilize them in construction and land grading. There is a great need for these materials in construction.

Trap rock is a common name for a rock form found over a large portion of Connecticut. This rock is very old and was formed when lava flowed out over the land surface through fissues. The rock breaks off in large blocks giving a steplike appearance. Trap is the shortened form of a german word trappen which means step. And so we use the term trap-rock.

Trap rock serves a multitude of purposes whether it is utilized in large block or smaller gravel-like pieces. In the beginning of this unit we listed many trap rock uses which include bases for roads, drainage areas and septic system drainage fields.

Gravel serves many of the same purposes as small pieces of trap rock. Gravel comes from a natural accumulation of rounded rock fragments in unconsolidated deposits. These fragments have a wide variety of sizes from good size rocks to pebbles or granules.

Sand is used mostly in the mixing of concrete and asphalt. Sand deposits have very small particles which are quite coarse and granular. They are not as fine as silt or clay.

Building over such deposits restricts and even eliminates the possibility of eventual use of these deposits as a resource. Well planned removal of these resources can leave the area suitable for alternative uses. The next slide, slide #17 shows a former gravel pit that is now being developed as a community recreation area. Such planning shows wise use of the land. Not only are the deposits under the soil layer utilized, but once the deposits are removed the land is available for future development.

Follow the brown ribbon representing the artifical fill for the Wilbur Cross Parkway from the top center of the map about 4 inches to the large irregular brown area. This area is artifical fill. According to the map key the upside down crossed shovels indicate that this is an operating sand and gravel pit. This area is a valuable economic resource to the region providing construction materials for community development.

Connecticut has a rich history of brick-making. Clay deposits have traditionally provided a source of material for brick production. At the southwestern end of the Wilbur Cross Parkway on the map, there are several blue areas with upright crossed shovels. This symbol indicates a clay pit. The area is colored blue because the clay pits fill with water. The pits become flooded because they are well below the soil surface and the water table. When a clay pit is in operation it is necessary to constantly pump out water and build dikes to keep out the river. The bar across the crossed shovels indicates that these clays pits are inoperative, but there are still active clay pits in the Quinnipiac Valley.

Deposits may also present some limitations for building just as the type of soil we build upon may or may not be suitable for a particular land use.

You may have noticed that there are three areas encircled and numbered on this map. We will analyze these three sites together using both the information given us from the surficial geology map about the deposit and information we have collected throughout this unit.

What is the deposit found on site #1? (Pause) The key shows the area is underlain by glacial till, a compact, nonsorted sediment. We mentioned earlier that till in places tends to be compact and therefore not very permeable. Low permeability could influence your on site septic disposal system's functioning. The filtration of the effluent will be slow but then again thorough.

There are no purple areas for bedrock outcrops on the site or nearby which indicates that bedrock is not close to the surface. From the topographic lines, we can see that the slope is moderate. Remember that steeply sloping areas generally have bedrock close to the surface and bedrock outcroppings are common. This site should then present few excavation problems.

The moderate slope means little difficulty in grading the site for access road construction or building sites. Unless the soil is easily eroded, a moderate slope such as this should not present serious erosion problem during construction. The moderate slope here could provide good drainage of water from the site. It may mean an attractive view for a housing development.

Let's take a look at site #2. What is the deposit underlying this site? (Pause) If we again look for the key, we find that the site is underlain by Ice-Contact Stratified Drift. We know that stratified drift is layered bacause of the forces at work during its deposition. Thus it is better sorted than till. Even though stratified drift may contain fine clays, it is more frequently composed mainly of sand and gravel. Thus the deposit is probably very permeable. If the effluent from an on site septic system is able to move very rapidly through the deposit, filtration may not be thorough.

Inland Wetlands

Birds chirping i[illegible]ackground. Soft wind transition to industry with appropriate sound (don't overkill by too much noise)

Slide #1 split Wetland/ Factory

Welcome to the industrial park of Manytowns, U.S.A. The site we are visiting consists of several light industries built during the last five years and the remnants of an inland wetland. The factories were built on this site for several reasons: land in this area could be purchased for fewer dollars per acre than other land in this community,...the area is close to major highways,... there is a stream close by for disposing of waste cooling water and treated effluents. In addition the land was of no "direct economic value to the community". The arguments for building on this site were carefully developed, but there were some flaws as we shall soon see...

A

One of the major reasons that the land was available for development relates to the fact that it was a wetland. Once the property was purchased and filled, the factories were built...the industrial park became a tax producing operation for the community and the wetland was destroyed.

Slide #2 Undisturbed Wetland

As you look at slide # 2 you will see an undisturbed wetland. . . As I traveled from the industrial site to the wetland you are studying in slide #2, a phrase from Ecclesiastes kept running through my mind. . .

> for every thing there is a season and
> a time for every purpose under heaven . . .
> a time to build, a time to tear down.

It would seem that as we study the wetland issue, we must be willing to objectively consider alternative uses of wetland areas. There are times when wetland areas can be used for specified types of development, there are times when wetlands should be left totally undisturbed.

Before spending time discussing alternative use patterns for wetlands, let's focus our attention on wetland structure and function.

Inland wetlands have been described by conservationists as one of our most precious resources. Support for this position has come from biologists, hydrologists, ecologists and soil scientists. These and other professionals in land use decision making recognize wetlands as valuable areas that have a multitude of specific values for communities.

- Defining inland wetlands presents some problems. There is no single definition which is totally acceptable to all of the individuals who are involved in studying wetland structure and function. To help illustrate this point, please turn to guide sheet #2... We would like to have you brainstorm for about 90 seconds and generate a list on guide sheet #2 of all of the factors which you feel are characteristic of inland wetlands. At the signal you should begin listing factors...after about a minute and a half, turn the recorder back on. Ready to start brainstorming? Then stop the recorder and begin!

Guide
Sheet #2
List of
Wetland
Characteristics

rog
o[illegible] for
ignal.
se birds
nd breezes
ackground

Inland Wetlands

Let's compare your ideas with those of scientists who are involved with wetland studies.

If you were a biologist, you would probably have generated a list of characteristic plants and animals which occupy inland wetlands. The specific plants and animals would depend upon the amount of water on or near the surface of the area, and the number of months per year the water level exists at these levels. Did you consider plants and animals as inland wetland indicators?

If you made any statements about water on or near the surface for part of the year, you would be considering the inland wetland from the perspective of a hydrologist. Hydrologists generally describe how a wetland functions in a water system. In addition, they are very concerned with the role of the inland wetland in maintaining water quality and quantity. Your list should only make reference to fresh water, as inland wetlands contain only fresh water.

Water obviously plays a major role in inland wetland structure and function. One important dimension relates to the interrelationships between the soil and water. Soil scientists define inland wetland areas in terms of soil types. Inland wetland soils are poorly drained. Poorly drained soils have water on the surface, at the surface. or close to the surface for a large portion of the year. In slide #3 you can see a soil profile of an inland wetland. Study the slide carefully...(pause 3 seconds) Do you see the gray, brown and almost orange areas in the

Slide
#3
Wetland
Soil
Profile

soil profile?...This type of soil has what is traditionally referred to as a mottled coloration. Most mottled soils are colored various shades of gray, brown, and yellow. The mottled effect is a result of the oxidation and reduction of iron compounds in the soil. Imperfectly and poorly drained soils have poor aeration and are nearly always mottled or gray. Are there any other clues in the slide that indicate that this might be an inland wetland area?....(Pause 3 seconds) Do you see the standing water in the bottom of the hole? The water is only a few feet below the surface...It is a definite indication that this is an inland wetland area.

In generating your list of inland wetland characteristics.

Did you mention anything about upland or lowland areas? If so, you would be using terms that geologists utilize in describing an inland wetland area. Geologists divide wetlands into two basic categories: upland and lowland wetlands. Turn to guide sheet #3. On Guide Sheet #3 Try and locate the upland and lowland wetlands on the diagram. (Pause 5 seconds) Have you found them?...If you study the diagram carefully some of the differences between upland and lowland wetlands will become apparent....The wetland labeled with a Roman Numeral I is representative of an upland wetland.

Guide
Sheet #3
Diagram o
Upland &
Lowland
Wetlands

Background
Music

Upland wetlands occur when the water table intersects the land surface. Look at the diagram...and follow the water table line from the right hand edge of the diagram to the left edge. Make note of the areas where the water table comes close to or intersects the soil surface? (3 second pause) Remember, when the water table intersects the land surface, or is very close to the land surface we have proper conditions for a wetland.

In addition to providing information on the water table, the diagram also describes the material underlying the wetland. In the upland area the bedrock is close to the land surface. Bedrock is impermeable to water and thus retards water drainage in this area.

The wetland area labeled with Roman Numeral II is representative of a lowland wetland.

Make note of the fact that the water table intersects the soil surface in this lowland wetland. In lowland regions we frequently find glacial deposits of sand, gravel, silt and porous soils underlying the wetland. These permeable materials often produce semicontinuous ground water reservoirs called aquifers. These aquifers provide major water holding areas. They provide significant quantities of water to wells and springs. The major water collection and storage areas of a community consist of surface waters, aquifers, and inland wetlands.

Guide Sheet #4

Now turn to Guide Sheet #4...(Pause 3 seconds) Study the diagram at the top of guide sheet #4 carefully...From this diagram we can see that wetlands are part of a major geologic-hydrologic system which forms a water continuim including wetlands, upland ponds and streams through lowland wetlands, lakes and rivers, into estuaries, coastal marshes and ultimately flowing out into the ocean. If you would like to spend some time studying guide sheet #4, turn off the recorder until you are ready to continue. (Interlude 2 seconds)

Let's summarize what we have determined so far by reviewing the list at the bottom of guide sheet #4. Inland wetland areas are more or less regularly flooded areas, where the water table stands above, at or near the land surface for a large part of the year. These areas may be described in terms of their wetness conditions, soil types and the types of vegetation which can grow in these regions.

Guide
Sheet #4
Summary
list.

Now let us turn our attention to the role that wetlands play in the total community. The value of the complex wetlands system cannot be overestimated. Inland wetlands help tame floods; keep streams and rivers flowing; and act as overflows for the ground water system. Wetlands also function to maintain and improve the quality and quantity of the water you drink. Inland wetlands function to provide you with these and many other valuable services free of charge. To emphasize the importance of wetlands to the community, we have prepared a list of the major wetland functions on guide sheet #5.

Guide
Sheet#5
Outline
of Inlan
Wetland
Function

Turn to guide sheet #5 and read through the outline of inland wetland functions. Turn the recorder off while you are studying the outline...turn us back on when you are ready to continue. (5 second musical interlude)

ring up
ackground
r insert
usical
nterlude

¶ The major functions of inland wetlands include regulation of water quantity and quality, flood control, sediment and erosion control, biological productivity and diversity, recreation, education as well as aesthetic and historic considerations. All of these wetland functions are subject to alteration if the wetland is disturbed.

The functions outlined in Guide Sheet #5 are functions which apply to undisturbed wetland areas. If a wetland has been affected by agricultural, recreational, residential or industrial activity, then some, or all of these wetland functions may be altered. Major changes in wetland structure in turn has an impact upon the wetlands ability to perform its "normal" functions.

Of all wetland functions, probably the most significant for mankind is their role in the hydrologic system. Wetlands minimize seasonal fluctuations in water table levels, they provide a place for water to expend its energy during periods of high water and in turn, they tend to release water during periods of drought. In addition, they filter sediment and some contaminants out of water supplies.

Ground water, that is the water beneath the land surface, is extremely important to our communities both in terms of quality and quantity. Ground water plays an important role in maintaining well water supply and stream flow between rainfalls and during long periods of drought. The quality and quantity of ground water depends upon both natural and man influenced conditions which effect wetland areas.

Wetlands do have a pollution neutralizing capability. Wetlands near industrial sites and heavily developed residential areas often receive great quantities of inorganic and organic materials. The wetland, as a biological system will utilize and concentrate many of these materials. Recent scientific studies have documented the ability of swamp or marshes to trap or alter pollutants carried in water. It is important to note that there is a limit to the pollutant neutralizing or cleansing capabilities of biological communities. Pollutant loads in excess of plant uptake, and of sufficiently toxic nature, cannot be utilized and subsequently become lethal elements within the system. When pollutants overload the wetland's ability to purify ground water, the ground water becomes contaminated.

In addition to the biological entrapment or alteration of pollutants, wetlands entrap silt laden waters and permit the silt lead to settle out. In the process, many pollutants adhere to the sediment particles and settle out with the silt. Extremely heavy sediment coming from erosion and construction activities can fill and destroy wetland areas.

Another major contribution of wetlands to the community relates to their ability to reduce flood damage. Inland wetlands reduce the impact of floods through their ability to slow and store flood waters, and to slowly discharge the water over a period of several weeks or months. In reservoir systems this particular wetland function increases the total water storage capacity of the system.

The construction of industrial sites, shopping centers, and residential housing on wetlands increases the potential for flood damage in two ways. First, it reduces the ability of the wetland to store flood waters and secondly, it places buildings in areas most likely to be affected by wetness or flooding A more detailed discussion of the effect of urban and suburban development on flood flows can be found in the audio-tutorial unit on hydrology.

Slide
#4
Slide
of
Flood
Wetlan

The ability of wetlands and watercourses to reduce both natural flood flows and increased flows due to urbanization stems from their ability to slow the downstream rush of water. In Slide #4 you can see a large quantity of water that is spread out on the wetland surface.

Most wetlands soils are not very porous. This coupled with the high water table in wetland areas prohibits the rapid infiltration of flood waters so water spreads out over the wetland surface and forms temporary reservoirs. This condition, technically known as ponding, is visible here in slide #4 in this slide. A 6 inch rise in the water level over a 10 acre wetland places 1,500,000 gallons of water in storage with no permanent harm to vegetation.

To the contrary if wetlands are destroyed the water which they ordinarily would hold now becomes run off and the water moves into storm sewers or adjacent streams.

On guide sheet #6 you will find a problem and an illustration which demonstrate the impact of development upon the water absorption capabilities of a wetland area. Work through the problem on guide sheet #6. Stop the recorder while you study your calculations...then, turn the recorder back on. (pause 5 sec.)

Surprised by the quantity of run off from the shopping center. Now, can you see why some wetland areas must be kept functional to absorb this run off!!! (Pause)

Natural vegetation and stream meanders, or the bends in the streams, also slow flood waters through physical resistance or friction. Soil erosion by water and the resultant sedimentation are often overlooked as problems resulting from suburban and urban development.

Erosion and sedimentation occur as a direct result of construction activities which remove vegetative cover and increase storm run-off. Storm run off and peak flows from urbanized areas greatly exceed that of agricultural or forested areas due to the impermeability of asphalt and concrete. As forests are cut agricultural lands developed and natural drainage channels constricted, the need for protective wetland buffers becomes more imperative. Wetland areas can help prevent flooding by absorbing/or holding runoff unless of course, they become developed too.

Slide
#5
Wetland
choked
with
sedimen

Inland Wetlands decrease the speed of flowing water and subsequentl function to remove and immobilize sediment. Flooding and erosion caused by construction often severely overload wetland systems. The wetland shown in the slide #5 has been choked with sediments. The wetland vegetation is no longer able to retain these sediments properly. The next storm may dislodge the sediments you see in slide #5 and carry them downstream. Protection of wetlands from severe sedimentation is of major concern to all.

Sediments from soil erosion may fill up reservoirs; increase water turbidity; fill in storm drainage systems; decrease the amount of dissolved oxygen available for aquatic organisms and create many other problems.

The role of wetlands in agriculture provides an interesting springboard to consideration of the biological productivity of these unique areas. Many wet meadows provide a good source of pastures for livestock. But, unfortunately in many New England States, declines in farming have resulted in the abandonment of many of these productive pastures. As a result these areas have reverted to their original wetland functions and along with other wetlands play an important role in supplying water and suitable habitat for many types of plants and animals. An inland wetland provides wildlife with an abundance of clean water, food and shelter. In addition it provides ideal growing conditions for a wide variety of plant species.

Wetlands contribute immeasureably to the productivity of fisheries and wildlife. Many species of migrating birds depend directly upon our wetlands as breeding grounds and feeding areas. The condition of wetlands in one community can ultimately effect bird populations in areas thousands of miles away. Biological productivity is by no means limited to larger forms of wildlife and fisheries. Countless micro - and - macroscopic plants and animals depend directly and indirectly upon wetlands for water, food and habitat.

Slide #6
Bog

Many wetlands represent unique natural areas. Slide #6 will show you an open water bog.

Many plants found here in the bog are rare.

The bog is extremely fragile. The Floating Mat that you see in the central portion of the slide can easily be trampled. Unfortunately, careless visitors to the bog often destroy many of the unique organisms they have come to observe. Bogs such as the one you are observing are unable to recover quickly from destruction or overuse.

Wetlands are of great recreational value. As population numbers increase, more and more people will be making use of our waterways for recreational purposes. Inland wetlands play an obvious role in maintaining the quantity and quality of bodies of standing water, rivers and streams.

Wetlands may be used recreationally for activities such as fishing, boating, hunting, bird watching, picnicing, hiking, and photography. In slide #7 you will see a wetland that is used by a model flying club as a flying field. By careful management, wetlands can be used for recreation and still perform their natural functions.

Slide #7
Flying
Field o
Wetland

Pristine wetlands, now rapidly on the decline, provide a measure of environmental quality in the form of open space. These wetlands have become sanctuaries where modern man can escape the pressures of urban living.

Inland wetlands are also extremely important to our educational systems. These unique living laboratories furnish school students and other citizens of the community with resources for research and education in ecosystem structure and function.

The ability of the wetland to provide this service depends directly upon people. As the wetland becomes progressively utilized its usefulness for ecosystem research is compromised. Instead of furnishing baseline scientific data the wetland thus becomes a testimonial to our inability to live in harmony with our environment. Ironically, observing man's impact on wetlands still provides an educational benefit.

Wetlands obviously fulfill many roles in our communities. They are valuable as open space areas and they provide pleasant aesthetic areas for recreation. While providing the community with visual and aesthetic benefits, wetlands also maintain an adequate supply of water, they prevent flooding or reduce the impact of flood waters and they constantly function as a water purification system.

Up to this point in the Wetlands unit, we have talked about the structure and function of wetlands in general terms. At this point, we will focus our attention on specific wetland plants and classes. This section of the unit may be especially useful if you become involved in identifying wetland areas in your community. The plants are good indicators of both the ground water condition in the area and the soils underlying the area.

Turn to guide sheet #7 on Inland Wetland Classes and place it next to guide sheet #8 A-Plant Key. Put the guide sheets together in front of the slide viewer. (Pause 3 sec.) Guide sheet #7 is a graphic representation of the eight Wetland classes developed by Francis Golet and Joseph Larsen. This system is used by the U.S. Dept. of Interior in their wetland classification system. The numbers found next to each plant will correspond to the number and name of the plant on guide sheet #8. If a plant on this

Guide
Sheet #7
Inland
Wetland
Classes

Guide
Sheet #8
Plant ke

list is found in one of the wetland classes listed across the top of the sheet you will find either a C or a P in the appropriate box. The letter C indicates that the plant is commonly found in that wetland class. But it does not mean that this is always the case. The letter P indicates that a particular plant may be present in that wetland class but is not usually abundant.

Slides are provided of each wetland class so that you will be able to compare the drawing to an actual wetland. If you need, or want additional time to study the guide sheets or slides in this section, simply turn off the recorder until you are ready to go on!!!

Gross differences in wetland types are most easily identified by observing the amount of surface water and indicator plants found in the area. These differences will be used as the basis for distinguishing between the wetland classes.

Take a look at slide #8. (three second pause). What wetland class would you predict this to be? If you predicted an open water class you are correct! The open water class is number 1 on your wetland class Guide Sheet. This wetland has water approximately three feet deep. Notice the water lilies growing on the waters surface with roots attached to the pond bottom. An open water class may also have only submerged plants such as wild celery. This type of wetland provides nesting and feeding habitat for a variety of animals.

Slide # 8
Open water
class

Slide number 9 is representative of a deep marsh. Look at the slide and try and identify the dominant plant type...Of course, cattails!!! Cattails are the dominant form of deep

Slide
#9
Cattail

marsh vegetation. You can see them located in the foreground of this slide. Deep marsh wetlands belong to class two on your classification sheet. This inland wetland class provides valuable water fowl habitat. Water fowl use these areas for mating, nesting, breeding and the raising of young.

Slide #10 depicts a shallow marsh...(wetland class #3). Shallow marshes most generally contain soft stemmed herbaceous plants. Do you see any common characteristics in wetland classes 2 & 3? (Pause) Once again, the common plant here is cattails. The distinction between shallow and deep marshes is based on water depth only.

Slide #10
wetland
class-3

The next slide number 11, is an aerial view of a flood plain along the Quinnipiac River. Vegetation which grows here is well adapted to periodic flooding and the accumulation of sediments. Scattered shrubs and trees are also found in this wetland class. The most common trees are red maples, willows and pin oaks. All of the larger trees are located on the higher ground.

Slide #11
Aerial view
of Q River
Plain

Now look at Slide #12. (pause 3 sec.) The meadows pictured in slide #12 occur primarily on agricultural land where mowing or grazing prevents the growth of trees or shrubs. Such a wetland may have a impervious layer such as hardpan beneath. Hardpan prevents the downward flow of water. (Pause) Now look at slide #13...(Pause 3 sec.)

Slide #12
Grazed
Wetland
Meadow
Slide

A high water table usually favors certain shrubs such as found in wetland class #6 over the trees found in a wooded swamp (Wetland Class #7) The organic deposits underlying both of these classes are shallow. Shrub swamps include vegetation such as alders, silky dogwood, highbush blueberry

Slide#13

and swamp azaleas. Notice the shrubs along the margin of the open water. The wooded swamp pictured in slide #4. is flooded only during the spring. Red maples are now the common tree found in this slide of an abandoned meadow. Shrubs such as spicebush or speckled alder may eventually grow beneath the trees. Wooded swamps offer great songbird diversity because of the different vegetation levels. These wetlands are also important to wildlife such as deer, raccoon and oppossum.

Slide # 14

Wooded Swamp - Red maples

Slide # 15

Bog slide

The bog pictured in the final slide illustrates a unique ecosystem. This bog developed in an old glacial lake. The yellow trees in the center of the slide are tamaracks. Tamaracks, which grow on the Floating Mat of moss, will slowly cover all the open water. As the mat moves across the lake plant debris accumulates beneath it and fills the lake. Some bogs in the Northeast are beyond the floating mat stage and have evolved into forests.

Atlantic White Cedar is commonly found in New England Bogs. Many herbs and shrubs which grow on and around the bog are found in no other ecosystem.

This completes the Inland Wetland Unit Part I. The other side of this tape addresses the issue of inland wetland regulation in Connecticut and includes a hypothetical case study.

(Turn Recorder Off)

Inland Wetlands Part II

Wetland sounds

Wetlands have proved to be an economically valuable resource to communities as water storage and water purifying areas. In addition, wetland areas are of great aesthetic, educational and biological value. Having outlined the various contributions wetlands make to communities, it might seem that communities would be extremely protective of these areas...this is not the case. Wetlands have been systematically used for land fill sites and assorted forms of development because of their relatively low dollar cost in comparison to surrounding land.

Construction sounds

Many studies, much legislation, great expense and plain hard work have been expended to preserve and regulate these irreplaceable resources. Still, irrepairable damage continues and insensitive attitudes persist. The opponents of wetland regulation argue that without development, wetlands are economically non-functional. Unfortunately, they have overlooked the many tangible and intangible benefits which wetlands provide for a community. Wetlands do have vital functional benefits that can be measured in dollars and cents. Many of these benefits are outlined in part I of this wetlands unit.

Let's assess man's impact upon wetlands from a historical perspective...

The destruction of inland wetlands began when the colonists first settled this country. Rivers and streams provided early American settlers with the means of transportation and a constant supply of inexpensive power. As a result communities sprang up on the lowlands and floodplains along river corridors. To protect the property of the settlers, levees were built to control flood waters. As time progressed, swamp land was drained for farm land and for a variety of types of construction. In many areas of the country, the farming of these former wet soils has contributed significantly to the production of grain and livestock. In addition, since colonial days manufacturing plants built beside our rivers and streams have played a major role in our expanding economy. Many waterways have been modified to benefit transportation, manufacturing and other industry.

Changes in these wetland areas have provided definite economic benefit, but there have been costs associated with development as well. In many cases valuable wetland area have been modified without any knowledge of the ultimate effect of the alterations. As a result, many wetlands have been destroyed and their potential contribution to communities has been eliminated . Turn to guide sheet #2 (pause 2 sec.)...

On Guide Sheet #2

we have generated a list of activities which have altered or destroyed wetland areas. The list is not exhaustive. You may want to add some activities to the list. Turn off the recorder while you review guide sheet #2 (Pause 3 sec.)

Guide Sheet #2 List of activities destroying wetlands

First of all, inland wetlands have been used as landfills because they were considered to be useless idle land. This activity has lead to the contamination of ground water in many communities. This aspect of wetland usage will be discussed in more detail in the unit on hydrosystems.

Inland wetlands have also been extensively drained and filled for residential, commercial or industrial development. Besides destroying the natural functions provided by wetlands, construction activities have resulted in soil erosion, sedimentation and increased rate of rain water run-off.

Homes or other buildings constructed on drained or filled wetlands.

3

are apt to provide homeowners with some unpleasant surprises. Consider the plight of the homeowner whose house was constructed on a wetland soil known as peat and muck. To make the site buildable the wetland was drained. As the soil dried it began to shrink and the foundation of the house responded to the changing soil condition by settling. This settling or shrinking condition is termed subsidence. Subsidence results in cracked morter, cracked and tilted walls and sloping floors. Although the cost of land in this area was low and invited development, the initial savings has been more than off set by the cost of repairing damage caused by subsidence.

There are additional problems which often surface when wetlands are used for housing development. Because of the high water table in wetland areas, basements in houses built on wetlands are often flooded. In addition, the high water table inhibits the proper operation of septic systems causing sewage to be carried to the surface or into on-site wells, thus contaminating the water supply. Before developing wetland areas for housing, a careful analysis should be made of the developments impact upon the wetland, and the wetlands future effect upon housing built on the wetland.

Large tracts of wetlands have been used for industrial development. Development of these wetlands requires that they be drained and/or filled before construction can begin. Since filling these areas is costly, there must be some interesting reason for building industrial plants in these areas. Turn to guide sheet #3A (Pause 2 sec.). On Guide sheet #3A make a list of some reasons which you feel might explain why wetlands have been chosen for industrial development. Before starting your list, turn the recorder off...Turn the recorder back on when you are ready to continue.

Guide
Sheet #3

Now that you have considered why industrial parks have been earmarked for inland wetlands, let's compare your list with some of the factors which developers feel encourages this type of land use decision. If we discuss issues which you haven't listed, add them to your list.

First of all, inland wetlands are generally large, level tracts of land. This eliminates the problems associated with constructing plants and warehouses on hillsides. In addition, few people enjoy living next to an industrial park, so by placing the park on a wetland away from the rest of the community few people will be offended. In this way, industry can be out of sight - out of mind but still providing valuable tax dollars.

From an economic stand-point, inland wetlands can often be purchased at a relatively low price, even after the added expenses of draining and filling the wetland have been considered. In many communities, wetlands are the last undeveloped parcels of land which can be zoned for industrial development. These are a few of the major reasons for developing wetlands. Did you have any additional considerations?

Now, let's take a look at local zoning practices -have you considered the role planning and zoning practices play in this scheme?

Planning and zoning policies often encourage industrial use of inland wetlands by earmarking these areas for only industrial development. To complement this practice zoning boards frequently fail to set aside enough other land for industrial use. Thus, industrial concerns often have little choice in deciding which land to develop.

As you can see, the past and present human impact on the inland wetland ecosystems has occured because the value of these areas in an undisturbed state is not understood or valued by the community. It has only taken a few decades to dramatically alter and destroy many of these valuable complex ecosystems. Wetlands must be mangged as part of an entire hydrologic system. They can not be treated as isolated units. We can not afford to destroy these areas without assessing the environmental and economic impact of such action.

One of the factors which encourages wetland development, is the comparatively low purchase price of these areas. Recognizing the importance contributions which wetlands make to a community, what do you feel causes wetlands to have such low values compared to other pieces of land in a community?

Well, part of it relates to the fact that wetlands are different from other parcels of land..they are frequently considered to be wet, useless pieces of ground and are thus sold for relatively low prices. Unfortunately private market prices do not reflect the full value of these resources to society. This results from the fact that the full dollar value which a functioning inland wetland represents to society is difficult to estimate. How do you place a dollar value on wetlands that are providing us with an abundant supply of clean water or protecting our homes from the tragic and costly damages created by raging flood waters? What do you charge the teachers, hunters, fishermen, bird watchers, photographers or hikers for the privilege of using an inland wetland for their recreation? How do you balance the books by saying that a wetland is valuable to our community as open space? How much money should we allocate for providing a new home and breeding ground for many species of wildlife that rely on inland wetlands for all of their needs?

There are many intangible benefits which any wetland represents. Each one has obvious value, but the true dollar value is difficult to determine.

When a selling price is agreed upon between a wetland landowner and a buyer, can the owner and the buyer be expected to make a decision that will make maximum use of the wetland as a community asset? How can they be expected to make a decision based on the highest social benefit if neither the landowner nor the developer face the full social costs of development?

How can we close this gap between a selling price established in the development market and a price which reflects all the dollar values a wetland brings to society? (Pause 2 sec.) This is not a simple question to answer. As a matter of fact, many people in universities and government agencies are attempting, but have not yet succeeded, in answering these question. Why is finding the answer so difficult? Let's explore that question by looking at a list of wetland beneficiaries. Turn to guide sheet 3B, turn off the recorder and review the list of wetland beneficiaries. (Musical interlude - 5 sec.)

Guide Sheet 3B

In reviewing the list, did you find categories which describe ways in which you benefit from wetlands? All of us are wetland beneficiaries whether we are conscious of the fact or not! After discovering all of the hidden benefits a wetland provides it is difficult to understand why anyone would allow them to be destroyed without first assessing the impact of planned development on the wetland site. Look at the list again and try to place a dollar value on each benefit which you derive from wetlands...Write these dollar values in the right hand margin of the guide sheet. (Pause) If you need more time, turn the recorder off until you are ready to proceed.(Pause)

What is the total value of the wetlands to you? (Pause) Would you be willing to pay to continue to receive these benefits if the cost was charged on an annual basis?

A summary of the key questions about wetland values is provided for you on Guide Sheet 4A. (Pause 3 sec.)

Guide Sheet 4 Questions on wetland values

Who are the beneficiaries of wetland function? What are the beneficiaries willing to pay for these benefits? Which wetlands provide the greatest benefits and which ones provide the least? Think through the questions on Guide Sheet 4A.

There are no easy solutions to the problem of inland wetland value assessment. But, we can begin to close the value gap by understanding the intangible benefits we are enjoying and potecting the source of those benefits.

We must establish a balance between short term profits and long term environmental deterioration. It is very difficult to take a long term view when inflation is reducing the value of every dollar we earn, yet a long term perspective is absolutely necessary for sound planning purposes.

In response to increased pressure upon Connecticuts wetlands, the state legislature has taken a significant step toward the proper long term management of our wetlands. In May of 1972, Connecticut Public Act 73-155, the Inland Wetlands and Water Courses Act, was passed by the legislature and signed into law by the Governor. On July 1, 1974 the Act went into effect.

Since approximately 20 percent of the land in the state of Connecticut comes under the regulatory powers of this act, a large number of questions surfaced. These questions are summarized on guide sheet 4B.

What does this act mean to the citizens of Connecticut? What is an inland wetland? Who does the regulating? What kinds of activities does the act regulate? What criteria are used in making a decision on the use of any inland wetland?

These are the major questions which immediately came to the minds of many wetland landowners as they became aware of the law. The initial response was mixed. Many landowners feared that all development on or bordering wetlands would be stopped. Some conservationists felt that the wetlands were finally preserved for posterity. Both groups were wrong.

The Inland Wetlands Act was designed to regulate wetland usage...not to preserve wetlands. By following the guidelines set forth in the act, communities can see to it that their wetlands are used for the community. Some activities will be prohibited on wetlands while others will be permitted. In all cases, proper review procedures will prevent improper usage of this valuable resource. In order to convey the feelings of the Connecticut State Legislature concerning the value of these wetland areas and the importance of their regulation, we have included Section 1 of the Act at the top of Guidesheet #5. Follow along as we read through this important statement.

Guide Sheet 5

9

AN ACT CONCERNING INLAND WETLANDS AND WATER COURSES

A. Section 1. The inland wetlands and water courses of the State of Connecticut are an indispensable and irreplaceable but fragile natural resource with which the citizens of the state have been endowed. The wetlands and water courses are an interrelated web of nature essential to an adequate supply of surface and underground water; to hydrological stability and control of flooding and erosion; to the recharging and purification of ground water; and to the existence of many forms of animal, aquatic and plant life. Many inland wetlands and water courses have been destroyed or are in danger of destruction because of unregulated use by reason of deposition, filling or removal of material, the diversion or obstruction of water flow, the erection of structures and other uses, all of which have despoiled, polluted and eliminated wetlands and water courses. Such unregulated activity has had, and will continue to have, a significant, adverse impact on the environment and ecology of the State of Connecticut and has and will continue to imperil the quality of the environment thus adversely effecting the ecological, scenic, historic and recreational values and benefits of the state for its citizens now and forever more. The preservation and protection of the wetlands and water courses from random, unnecessary, undesirable and unregulated uses, disturbance or destruction is in the public interest and is essential to the health, welfare and safety of the citizens of the state. It is, therefore, the purpose of this act to protect the citizens of the state by making provisions for the protection, preservation, maintenance and use of the inland wetlands and water courses by minimizing their disturbance and pollution; maintaining and improving water quality in accordance with the highest standards set by federal, state or local authority; preventing damage from erosion, turbidity or siltation; preventing loss of fish and other beneficial aquatic organisms, wildlife and vegetation and the destruction of the natural habitats thereof; deterring and inhibiting the danger of flood and pollution; protecting the quality of wetlands and water courses for their conservation, economic, aesthetic, recreational and other public and private uses and values; and protecting the state's potable fresh water supplies from the dangers of drought, overdraft, pollution, misuse and mismanagement by providing an orderly process to balance the need for the economic growth of the state and the use of its land with the need to protect its environment and ecology in order to forever guarantee to the people of the state, the safety of such natural resources for their benefit and enjoyment and for the benefit and enjoyment of generations yet unborn.

The regulated areas discussed in the Act include inland wetlands or water courses as defined in the act. Inland wetlands are all soils that are very poorly drained, poorly drained, alluvial, or floodplain as categorized by the National Cooperative Soil Survey of the Soil Conservation Service, U.S. Department of Agriculture. Water courses are all water bodies, 10

natural or man-made, including rivers, lakes, streams and ponds. Swamps, bogs and marshes are also specifically included in the definition of water courses.*

A regulated activity is an activity on an inland wetland or water course involving removal and deposition of material, obstruction, construction, alteration or pollution of a regulated area.

A permitted use is an activity which is allowed on a regulated area either as a right (e.g., farming) or allowed provided the activity does not distrub the natural and indigenous character of the land.

To gain a better understanding of the act study Guide Sheet 5B. Turn the recorder off while you study the provision of the Inalnd Wetland Act. When you are ready to continue, turn the recorder back on. Guide Sheet 5B

Now that you are familiar with the basic provisions of the Inland Wetlands Act, let's briefly consider some of the problems local regulatory agencies and DEP are faced with in administering the Act.

The first basic problem is boundary deliniation. Where do we draw the lines indicating wetland boundaries? Using soils as a means of defining a wetland boundary does not eliminate all the problems. Boundary deliniation is difficult even with a detailed soils map, because of the map scale used and mapping errors. To appreciate the problem, consider the fact that a soil boundary line on a detailed soils map represents a strip of ground about 25 feet wide. To compound this problem, detailed soils surveys have only been completed for 80 percent of the state of Connecticut. The remaining 20 percent is being surveyed at a rate of 200,00 acre per year and the entire state will be mapped by 1980.

Administration of the Inland Wetlands Act is made difficult because the act is a unique piece of legislation. It does however represent a new and effective tool for land use planning...One issue the Inland Wetlands Act raises, focuses on public attitudes towards governmental control. Where do we draw the line between private and public rights? Up pops the age old question should private individuals have the right to have complete control over their property, or should the government be able to regulate a private citizens use of his land for the overall good of society? It seems apparent that there is now a need for private citizens and government to join forces in managing lands that have great public and private values. Under the guidelines of the Inland Wetlands Act, the best interests of all parties concerned with wetland utilization are weighted. Finally, when a decision is made, it represents objective decision making, not emotional protectivism or blind profiteering.

In an effort to permit you to gain a real insight into the land use decision making process we have designed a simple simulation. You are to review a hypothetical project that has been proposed for development on an inland wetland. As chairman of the Inland Wetland Commission of Wetford,

Connecticut you must make a decision as to whether or not the proposed project should go ahead or should be prohibited. To assist you in your planning, we have prepared a summary sheet on inland wetland functions on guide sheet number 6. If you are not familiar with the material on guide sheet 6 stop the recorder and study the guide sheet. When you are ready to continue, turn the recorder back on. (Pause 5 sec.)
Now that you are familiar with the function of inland wetlands, turn your attention to Guide Sheet #7 & 8.

In your role of Commissioner, you have just received a set of plans for construction of a subdivision of quality homes called "Marsh Estates". The construction plans are printed on Guide Sheet 7. Guide Sheet 7 is in overlay form so that it can be superimposed over Guide Sheet 8. Guide Sheet 8 is a map of the site. (slight pause) Use the map on guide sheet # 8 to delineate the wetland areas on the site plan.

Guide Sheet 6

Guide Sheet 7

A matrix which you will use in your evaluation is found on guide sheet #9. Have you been able to locate all of these guide sheets?...Turn the recorder off for a few minutes and review the material on guide sheets 7,8,9. When you are ready to continue, turn the recorder back on.

Guide Sheet 9

Well, here we go...let's begin by reviewing the site specifications as outlined in the proposed plan on guide sheet #7. As we go through the list of specifications, locate them on the site plan.

The project will consist of eight quality built homes. This number permits each home to be surrounded by adequate open space and will easily accommodate the required septic fields. Each house will have a septic tank with leaching fields.

There will be an asphalt road, "Cattail Court", with a cul-de-sac. The road will go through the center of the development.

Drainage tiles will be placed under the entire area. These pipes remove excess ground water and will empty into a four foot diameter pipe. The four foot diameter pipe will carry this water into the relocated stream.

A twenty foot high beam, or reinforced concrete wall will be built to keep flood waters away form the development during high flow periods.

As you study each of the design characteristics think of the construction activity which must take place to reach the goals outlined in the plan. The construction operations are listed across the matrix in the center of the page. (Pause) On the left border of the matrix at the top of the page you will find a list of project design considerations. Each design consideration will involve some construction activity. Go down the list of project activity and check off each part of the project design which requires either excavation of filling. Stop the recorder while you carry out this task. (Pause)

The next activity involves the identification of drainage requirements. Check off any of the parts of the project design that require changes in the natural drainage pattern found on the map. (Pause 5 sec.) In order to get a true picture of drainage, include all aspects of the project design which require construction of impervious surfaces. This will include rooftops and pavement. (Pause 3 sec. Another aspect we must not overlook is stream dredging and relocation. These are important on-site activities and should be considered. Finally, parts of the project design which require the installation or operation of a septic system must be analyzed-Review what you have done...if necessary stop the recorder for a few minutes...while you study over this section of the Guide Sheet.

Now that you have completed the initial part of the evaluation you must consider what total effects the project will have on each of the natural wetland functions listed on the left border of the matrix at the bottom of the page Turn recorder off and review Guide Sheet 6 to familiarize yourself with each of the wetland functions.

Now you must consider each activity listed in the central construction column and analyze what effects each one of those activities will have on the ability of the wetland to perform its function.

Start by assessing the impact of surface excavation on each wetland function. Use a minus sign to indicate a negative effect, a plus sign for a positive effect and a zero for no effect. You may elect to write in modifiers such as major or slight to reflect the degree of impact. Take all the time you need in making your decision on this permit application. Total up the pluses and minuses This is not a test: it is only a way of helping you to understand the entire inland wetland "concept". There are no right or wrong decisions. Turn off the recorder while you complete this activity. When you are ready to continue, turn the recorder back on. (Pause)

Now that you have completed the matrix. Decide whether or not the project should be approved, disapproved or approved with restrictions. Compare your matrix to the matrix prepared by another member of your group or community. See how your analysis differs from theirs and discuss these differences in an effect to see how you both arrived at your decision.

Some of the real problems posed by specific kinds of activities are outlined for you on guide sheet #10. At the conclusion of the unit, you may want to study the chart and reevaluate your decisions on the Marsh Estates site plan.

As you can see, there are many factors to be considered in analyzing proposals for the utilization of wetlands. By now, you have at least a surface understanding of the issues. For more detailed information on the subject please refer to the books listed in the bibliography. Good luck in your future wetland regulation activities.

OPEN SPACE UNIT

WELCOME TO THE UNIT ON OPEN SPACE. IN THIS UNIT, WE WILL BE DISCUSSING THE VARIED MEANINGS AND VALUES OF OPEN SPACE. THE TERM OPEN SPACE HAS RECEIVED A GREAT DEAL OF USAGE DURING THE PAST FEW YEARS. QUITE FREQUENTLY, AT TOWN MEETINGS, OR IN THE STATE LEGISLATURE, REFERENCE IS MADE TO THE PURCHASE OR RETENTION OF LAND FOR OPEN SPACE. FURTHERMORE, ENVIRONMENTAL PLANNING AGENCIES AT ALL LEVELS OF LOCAL, STATE, AND FEDERAL GOVERNMENT FOCUS THEIR ATTENTION ON THE PRESERVATION, MANAGEMENT AND USE OF OPEN SPACE.

JUST WHAT IS OPEN SPACE? WHY HAVE LOCAL AND STATE GOVERNMENTS BECOME SO INTERESTED IN PURCHASING, PRESERVING, AND MANAGING OPEN SPACE? ARE OPEN SPACES IN DANGER OF BEING LOST? IF SO, WHAT FORCES OR PRESSURES ARE ENDANGERING THEM? WHAT CAN WE DO TO ENSURE THE PRESERVATION OF OPEN SPACE? ARE THEY WORTH SAVING, OR PERHAPS ARE TRADEOFFS ACCEPTABLE FOR THE LOSS OF OUR OPEN SPACE?

THE ANSWERS TO MANY OF THESE QUESTIONS WILL PROBABLY OCCUR TO YOU AS YOU PROCEED THROUGH THIS UNIT.

YOU MAY BE SURPRISED TO LEARN THAT ONE OF THE MAJOR PROBLEMS ENCOUNTERED IN THE DEVELOPMENT OF EFFECTIVE STRATEGIES FOR THE PURCHASE AND CONSERVATION OF OPEN SPACE HAS BEEN RELATED TO THE AMBIGUITY OF THE CONCEPT OF OPEN SPACE. THIS STEMS FROM THE FACT THAT WE TEND TO PERCEIVE OPEN SPACE AS BOTH AN ENVIRONMENTAL AND A SOCIOLOGICAL PHENOMENON. THAT IS, WE TEND TO ASSOCIATE OPEN SPACE WITH NATURAL ENVIRONMENTS SUCH AS STREAMS, WOODS, BEACHES AND AGRICULTURAL LAND. THIS IS PERHAPS THE MOST COMMON ASSOCIATION. IN A SOCIOLOGICAL SENSE, HOWEVER, OPEN SPACE MAY REFER TO RELATIVELY SMALL LAND UNITS WHICH PROVIDE AVENUES OF GREENERY AND OFFER A SENSE OF RELIEF AND PRIVACY TO US AS INDIVIDUALS. THUS, A CITY PARK, ZOO, CEMETARY OR EVEN A VACANT LOT WOULD BE A FORM OF OPEN SPACE. THE BASIC DIFFERENCES IN THE SIZE OF OPEN SPACE AREAS HAS LED TO A DELINEATION BETWEEN MACRO OPEN SPACE AND MICRO OPEN SPACE AREAS. BY MACRO OPEN SPACE WE REFER TO LARGE AREAS OF UNDEVELOPED LAND. MICRO OPEN SPACE IS THEN DEFINED AS RELATIVELY SMALL AREAS LOCATED IN GENERALLY BUILT UP, INDUSTRIAL MUNICIPAL, AND RESIDENTIAL AREAS.

DESPITE THE FACT THAT LAND USE PLANNERS ARE IN GENERAL AGREEMENT THAT OPEN SPACE IS DESIRABLE, THERE EXIST MANY DIFFERENT VIEWS CONCERNING THE NATURE AND USE OF OPEN SPACE.

ON GUIDE SHEET #2, THERE ARE FOUR QUOTES DESCRIBING INDIVIDUAL PERSPECTIVES ON OPEN SPACE. READ ALONG WITH ME AS WE DISCUSS THE FOUR VIEWS OF OPEN SPACE PRESENTED ON GUIDE SHEET #2... ALDO LEOPOLD, ONE OF AMERICA'S FIRST AND FOREMOST CONSERVATIONISTS SUGGESTED THAT: "WILDERNESS IS THE RAW MATERIAL OUT OF WHICH MAN HAS HAMMERED THE G.S. #2

ARTIFACT CALLED CIVILIZATION."

SLIDE #1

It is easy to see where Aldo Leopold placed his priorities. Now look at slide #1, as we contrast Leopold's VIEW WITH THAT OF NEW YORK WRITER RICHARD GOLDSTEIN WHO WROTE: "I FIND I AM DISORIENTED BY SPACE. NEW YORK CITY HAS TAUGHT ME THE SOLACE OF WALLS. I FEEL MORE COMFORTABLE IN A SUBWAY THAN IN A FIELD, MORE WILLING TO CONCENTRATE ON SOMETHING WITH MOMENTUM THAN A LANDSCAPE THAT WILL NOT FLICKER OR REVOLVE. I DO NOT ABSORB SCENERY: RATHER, IT TURNS ME MEDITATIVE AND REMOTE. WALKING THROUGH THE WOODS, I FALL INTO THAT SELF ENCLOSING CONTEMPLATION WHICH ONE ERECTS TO PREVENT BOREDOM."

SURELY, NO GREATER DISPARITY COULD EXIST THAN THAT EVIDENT BETWEEN THESE TWO VIEWS. WHAT THESE DIFFERING VIEWS OF THE CONCEPT OF OPEN SPACE DO IN FACT, IS PRESENT US WITH A REALIZATION OF THE DIVERSITY OF HUMAN NEEDS AND DESIRES. THEREFORE, IN SETTING UP AND PLANNING OPEN SPACE FOR THE PRESENT AND FUTURE WE OUGHT TO PROVIDE A RICH DIVERSITY OF SPACES WHICH MATCH THE DIVERSITY OF HUMAN NEEDS.

BEING AWARE OF THIS, THE CONNECTICUT LAND PLANNING COMMISSION STATED THE FOLLOWING DEFINITION OF OPEN SPACE: "OPEN SPACE IS GENERALLY UNDEVELOPED, OR PREDOMINATLY UNDEVELOPED LAND WHICH HAS VALUE FOR ACTIVE OR PASSIVE RECREATION". FURTHERMORE, "TO BE OPEN SPACE, LAND NEED NOT BE ENTIRELY UNDEVELOPED OR UNBUILT UPON. PARKS, GREENBELTS, FARMS, GOLF COURSES, A BACKYARD, A ZOO, OR A CEMETARY MAY ALSO BE INCLUDED IN THE DEFINITION OF OPEN SPACE. OPEN SPACE MAY ENCOMPASS A WIDE VARIETY OF LAND USES WHICH HAVE LOW ECONOMIC RETURN AND LOW FREQUENCY OF USE BY A SINGLE INDIVIDUAL." BECAUSE OF THE LOW ECONOMIC RETURN ON THESE AREAS, PUBLIC ACTION AND CONTROL IS THE MOST PROBABLE METHOD OF PRESERVATION. NOW LOOK AT SLIDE #2.

SLIDE #2

A DEFINITION VERY SIMILAR TO THAT OF THE COMMISSION ON OPEN SPACE HAS BEEN DEVELOPED BY METROPOLITAN BOSTON. IN THEIR OPINION, THE TERM OPEN SPACE DOES NOT DESCRIBE A PARTICULAR TYPE OR USE OF LAND. IT IS SIMPLY A PREDOMINATLY VACANT LAND OR WATER AREA OF SUFFICIENT SIZE, UTILITY OR BEAUTY THAT ITS PRESENCE IS A PUBLIC BENEFIT.

WHICH CONCEPT OF OPEN SPACE BEST FITS YOUR FEELINGS -- LEOPOLD'S, GOLDSTEIN'S, BOSTON'S, OR THE COMMISSION'S? TO HELP YOU identify your personal open spaces and CLARIFY YOUR FEELINGS TOWARDS SPACE IN GENERAL, COMPLETE THE ACTIVITY IN PART B OF GUIDE SHEET #2. THE ACTIVITY FOCUSES ON SPACE IN YOUR PERSONAL ENVIRONMENT.

BEGIN BY COMPLETING THE LIST OF SPACES IN YOUR PERSONAL LIFE. THINK OF YOUR MOVEMENT THROUGHOUT THE ENTIRE DAY. WHAT PLACES DO YOU VISIT? WHERE DO YOU FIND PEACE AND QUIET DURING THE DAY OR IN THE EVENING? WHAT SPACES DO YOU ENJOY MOST? WHAT PLACES DO YOU ENJOY THE LEAST? AFTER YOU ARE FINISHED WITH YOUR LIST, RATE EACH SPACE IN TERMS OF ITS IMPORTANCE TO YOU. TURN THE RECORDER OFF WHILE YOU THINK AND WRITE. (PAUSE)

NOW THAT YOU HAVE FOCUSED YOUR ATTENTION ON THE VARIOUS TYPES OF SPACE WHICH ARE OF

IMPORTANCE TO YOU IN YOUR DAILY ACTIVITY, LET US EXTEND OUR THINKING TO OPEN SPACE IN GENRAL.

ON GUIDE SHEET #3, YOU WILL FIND A LIST OF A VARIETY OF OPEN SPACE AREAS. IN YOUR
ESTIMATE ARE THESE AREAS OPEN SPACE? HOW IMPORTANT ARE THESE AREAS TO YOU? STOP THE G.S. #3
RECORDER, WHILE YOU WORK ON THE ACTIVITY ON GUIDE SHEET #3.

AS YOU LOOK AT THE LIST, TAKE NOTE OF THE FACT THAT ALL OF THESE KINDS OF SPACES EXIST IN THE STATE OF CONNECTICUT. BUT, THERE IS ANOTHER QUESTION TO BE ASKED ABOUT THESE AREAS. . . ARE AREAS SUCH AS THESE AVAILABLE FOR OPEN SPACE CLASSIFICATION AND USAGE? TO ANSWER THIS AND OTHER RELATED QUESTIONS LET US CONSIDER THE CONCEPT AND AIMS OF THE CONNECTICUT COMMISSION REGARDING OPEN SPACE IN MORE DETAIL.

AFTER MUCH STUDY, THE COMMISSION REACHED TWO BASIC CONSLUSIONS. FIRST, CONNECTICUT IS FACED WITH AN EXPANDING POPULATION AND; SECOND, ACKNOWLEDGED POPULATION EXPANSION WILL POSE A CONTINUING THREAT TO EXISTING AREAS CLASSIFIABLE AS OPEN SPACE. THE CONNECTICUT PLANNING COMMISSION THEREFORE IS CALLING FOR A GOAL OF A MINIMUM OPEN SPACE PATTERN TO CONSIST OF AT LEAST 25% OF THE STATE'S AVAILABLE LAND. ACCORDING TO A RECENT ISSUE OF THE CONNECTICUT CONSERVATION REPORTER ENTITLED "THE VANISHING LAND" APPROXIMATELY 700,000 ACRES OF THE STATE'S 3.1 MILLION ACRES ARE OPEN SPACE. THIS AMOUNTS TO ABOUT 44%, WHICH IS WELL ABOVE THE GOAL SET BY THE PLANNING COMMISSION. IT IS IMPORTANT TO REMEMBER, HOWEVER, THAT NOT ALL OF THIS LAND IS PERMANENTLY OPEN SPACE. MANY ACRES OF OPEN SPACE NOT
PROTECTED BY GOVERNMENT or private conservation organizations are continuously being converted
to more intensive uses. On guide sheet #4,
YOU WILL FIND A GRAPHIC REPRESENTATION OF CONNECTICUT'S PRESENT OPEN SPACE. G.S. #4
NOTE THAT, EXCEPT FOR VACANT LOTS IN CITIES AND TOWNS, THE OPEN SPACE IS IN FACT A KALIDIOSCOPE OF THE CONNECTICUT COUNTRYSIDE. (PAUSE 5 SEC.)

WHILE COGNIZANT OF THE NEED FOR A DIVERSITY OF OPEN SPACE LANDSCAPES, THE CONNECTICUT COMMISSION IS INTENT ON PRESERVING SPECIAL AREAS WHICH HAVE CRITICAL AND FREQUENTLY UNIQUE SCENIC, HISTORICAL, RECREATIONAL, ECOLOGICAL, AND OTHER ENVIRONMENTAL QUALITIES WORTH PRESERVING. AREAS WHICH ARE RECEIVING MAJOR EMPHASIS INCLUDE STATE PARKS AND FORESTS, AGRICULTURAL LANDS AND INLAND AND COASTAL WETLANDS.

LAND THAT IS CATEGORIZED AS OPEN SPACE CAN USUALLY BE DIVIDED INTO TWO CATE-

GORIES: LOCAL AND REGIONAL. LOCAL OR MUNICIPAL OPEN SPACES ARE USUALLY PARKS, RECREATION AREAS, CONSERVATION AREAS OR VACANT LOTS THAT MEET THE NEEDS OF A TOWN, CITY, OR LOCAL POPULATION. THE SCALE AND SIZE OF THE FACILITY IS DESIGNED TO SATISFY THE NEEDS OF ITS IMMEDIATE NEIGHBORS. STATE OR REGIONAL OPEN SPACE CAN INCLUDE LOCAL OPEN SPACE, BUT IT IS GENERALLY INTENDED TO MEET THE NEEDS OF A GREATER NUMBER OF PEOPLE. A STATE PARK, FOR INSTANCE, IS INTENDED TO SERVE MANY TOWNS RATHER THAN THE RESIDENTS OF A SINGLE TOWN.

IN 1974, THE CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION PREPARED A STATEWIDE COMPREHENSIVE OUTDOOR RECREATION PLAN REFERRED TO AS SCORP. THE CITIZENS SUMMARY OF SCORP IS INCLUDED IN YOUR KIT. SCORP IS THE STATE OF CONNECTICUT'S STRATEGY FOR EXPANDED OUTDOOR RECREATION AND INCREASED NATURAL RESOURCE PROTECTION. DO YOU KNOW HOW MUCH OPEN SPACE IS FOUND IN YOUR COMMUNITY AND ITS VICINITY? USE THE ACTIVITY ON GUIDE SHEET # 5, TO LOCATE OPEN SPACE AREAS NEAR YOUR TOWN. TURN THE TAPE RECORDER OFF WHILE YOU COMPLETE THE ACTIVITY ON GUIDE SHEET # 5. G.S. #5

YOU NOW KNOW WHERE THE OPEN SPACE AREAS ARE LOCATED WITHIN AND AROUND YOUR COMMUNITY. IN YOUR OVERALL EVALUATION, DID YOU FIND THE AMOUNT OF OPEN SPACE SUFFICIENT TO MEET THE NEEDS OF YOUR COMMUNITY? IS THERE SUFFICIENT OPEN SPACE TO MEET THE DEMANDS WHICH AN INCREASING POPULATION WILL PLACE ON THE AREAS IN ANOTHER 25 YEARS? WHAT CAN BE DONE TO PRESERVE OR INCREASE THE AMOUNT OF OPEN SPACE AVAILABLE TO MEMBERS OF YOUR COMMUNITY? WE WILL DISCUSS SOME POSSIBLE ANSWERS TO THESE QUESTIONS LATER IN THE UNIT.

DESPITE THE FACT THAT CONNECTICUT PRESENTLY HAS A LARGE AMOUNT OF OPEN SPACE, MANY PEOPLE BELIEVE THAT THERE IS CAUSE FOR CONCERN. OPEN SPACE ON A PER CAPITA BASIS IS RAPIDLY DWINDLING. DURING THE 13 YEAR PERIOD FROM 1959 THROUGH 1972 MORE THAN ONE HALF OF CONNECTICUT'S FARMS WERE SOLD OFF TO DEVELOPERS AND LAND SPECULATORS. SIMILARLY, FORESTS AND WOODLOTS ARE RAPIDLY BEING LOST AS POTENTIAL LONG TERM OPEN SPACE AREAS.

THIS BRINGS US TO A CRITICAL QUESTION. WHAT IS THE FUNCTION AND UTILITY OF OPEN SPACE? OR, PUT IN A CONTRARY WAY, IF OPEN SPACE IS RAPIDLY DISAPPEARING PERHAPS IT IS BECAUSE WE DON'T REALLY NEED IT. AFTER ALL, DO NOT THE PRIORITIES OF HUMANS AND THEIR TECHNOLOGICAL CIVILIZATION COME FIRST?

THINK ABOUT IT FOR A MINUTE. HOW WOULD YOU EXPLAIN THE NEED TO PRESERVE OPEN SPACE? WHY IS OPEN SPACE IMPORTANT TO A COMMUNITY? GUIDE SHEET # 6 LISTS FIVE FACTORS WHICH ARE CONSIDERED TO BE THE MAJOR FUNCTIONS OF OPEN SPACE. (PAUSE)

As you look at different types of open space areas, you will find that they perform different functions. In part B of guide sheet # 6 you will find a matrix G.S. #6 of open area types and functions. Evaluate each open area type, and put a check in each column which represents a function of that particular type of open space. Stop the recorder while you work on guide sheet # 6b!

Let us examine each of the major functions of open space as they are presented in Guide Sheet # 6 and consider the potential weight they carry as valid reasons for open space preservation.

Undoubtedly of primary importance to urban and suburban dwellers is the SLIDE #3 utility of open space for recreational activity. The establishment of recreational open space areas such as that shown in slide #3 (Pause) is often a direct response to citizen demand for increased recreational opportunities. It basically stems from the fact that today there are more people with more money and more leisure time than there have ever been before in the history of our country. This new breed of individual prefers a combination of solitary and family oriented recreational activities such as baseball, tennis, golf, hiking, picnicing, camping, bicycling and boating. Now look SLIDE #4 at slide #4. The Connecticut Commission is vitally interested in increasing the total acreage of state parks and forests. A similar response on the local level is reflected by the number of towns which have established town beaches, parks and nature centers. Furthermore, because recreational use of open space is expected to triple by the year 2000 the aquisition of open space sufficient to meet future demands assumes paramount importance.

The second major function of open space, the provision of an attractive SLIDE #5 community design, assumes particular importance on the urban and suburban level. See slide #5. Just why should open space be considered necessary for an attractive community design? The answer seems to lie in several basic human requirements. First, we seem to require diversity in our environments. In fact, when given the choice, we opt for diversity of our landscapes. Thus urban and suburban open space provide us with a welcome change of scenery which helps to alleviate the monotony of the concrete sprawl. Second, most humans have the seemingly inherent need for green things in their surroundings. The city dweller who raises house plants bears mute testimony to this need. Or, is it perhaps a fixture of our evolutionary heritage that we require some vegetation however sparse in our surroundings? Third, and perhaps most important, open spaces in heavily populated and industrialized areas provide us with a series of buffer zones between humans and their technological activities. These act as safety zones which help shield us from the noise and air pollution given off by airports, major transportation arteries and heavy industries. Open space areas greatly alleviate levels of pollution by

ACTING AS BARRIERS TO SOUND WAVES AND DUST PARTICLES IN THE AIR. THE NEED FOR AN ATTRACTIVE COMMUNITY DESIGN INCORPORATING OPEN SPACE IS FINALLY BEING REALIZED BY TOWN AND CITY PLANNERS. RECENTLY CONSTRUCTED MODEL CITIES IN FINLAND AND CANADA WHICH INCORPORATE THE USE OF OPEN SPACE FORMS CALLED GREENBELTS ARE CURRENTLY BEING STUDIED TO ASCERTAIN THE FEASABILITY OF WIDESPREAD ADOPTION. THE RESULTS, IT IS HOPED, WILL SHOW THE WAY TO EXCITING, ATTRACTIVE CITIES OF THE FUTURE.

COMMUNITY DESIGN CAN ALSO MAKE A LARGE DIFFERENCE IN THE QUALITY AND QUANTITY OF OPEN SPACE IN A COMMUNITY. THE IDEA OF CLUSTERING HOMES TOGETHER AND USING THE SURROUNDING SPACE AS COMMON GREENS, SQUARES OR RECREATION AREAS IS CENTURIES OLD: IT IS THE PRINCIPLE OF THE EARLY NEW ENGLAND TOWN. CLUSTER IS COMMONLY DEFINED AS THE REDUCTION IN SIZE OF INDIVIDUAL HOUSE LOTS IN A SUBDIVISION, AND THE COMBINING OF THIS CONSERVED LAND INTO A SHARED OPEN SPACE FOR ENVIRONMENTAL PRESERVATION AND RECREATION. THE ADVANTAGES AND DISADVANTAGES OF CLUSTER HOUSING WILL BE DISCUSSED IN THE SYNTHESIS AND LOCAL IMPLEMENTATION A-T UNIT.

G.S. #7

FOR PURPOSES OF THIS UNIT, LET US SIMPLY SAY THAT CLUSTER HOUSING DOES PERMIT THE USE OF OPEN SPACE IN COMMUNITY DESIGN. THE CONCEPT OF USING CLUSTER HOUSING TO PROVIDE OPEN SPACE IS ILLUSTRATED ON GUIDE SHEET # 7. NOTE THE OPEN SPACE AREAS CREATED BY CLUSTERING HOUSES IN PART A OF GUIDE SHEET # 7 IN CONTRAST TO THE DISTRIBUTING OF SPACE IN A NORMAL SUBDIVISION. NORMALLY, CLUSTERING DOES NOT INCREASE THE NUMBER OF HOUSES IN A GIVEN LAND AREA, BUT IT DOES CHANGE THE WAY IN WHICH THE LAND IS DISTRIBUTED AND USED.

AS A THIRD MAJOR FUNCTION OF OPEN SPACE, THE MAINTENANCE OF NATURAL PROCESSES FINDS ITS BEST APPLICATION IN RURAL AREAS. THIS IS PARTLY BECAUSE LARGE AREAS OF OPEN SPACE ARE GENERALLY NEEDED FOR THE HARMONIOUS BIOLOGICAL RELATIONSHIPS WHICH ARE PART OF A NATURALLY FUNCTIONING AND SELF MAINTAINING AND PRESERVING ECOSYSTEM. LARGE OPEN SPACE AREAS ARE NATURALLY TO BE FOUND IN RURAL AREAS. WE ARE FORTUNATE IN THAT SOME OF THE OPEN SPACE FOUND IN RURAL AREAS TODAY IS NOT SUITED FOR DEVELOPMENT. EXAMPLES OF SUCH OPEN AREAS ARE STEEP SLOPES, RIDGES, AND ROCKY HILLSIDES. THESE PROVIDE US WITH OPEN SPACE WHICH CONTAINS THE NECESSARY SIZED LAND AREAS PLUS THE ADDED BENEFIT OF THE INCREASED DIVERSITY OF LANDFORMS.

SLIDE #6

THERE ARE OTHER REASONS FOR RURAL OPEN SPACE PRESERVATION AS WELL. AS SHOWN IN SLIDE #6 SOME OPEN SPACE AREAS ARE HISTORICALLY SIGNIFICANT. THEY PROVIDE AN IMMEASURABLE CONTRIBUTION TO OUR HERITAGE AS A STATE AND AS A NATION. GENERALLY NO FURTHER AGREEMENTS NEED BE ADVANCED FOR THE PRESERVATION OF SUCH SITES.

G.S. #8

GUIDE SHEET # 8 CONSISTS OF THE BICENTENNIAL EDITION OF POINTS OF INTEREST. THE BOOKLET LISTS DOZENS OF HISTORICAL POINTS OF INTEREST IN CONNECTICUT. TAKE A FEW MINUTES TO LOCATE SOME OPEN SPACE AREAS NEAR YOUR COMMUNITY, WHICH PRESERVE HISTORICAL SITES. STOP THE RECORDER WHILE YOU LOOK AT POINTS OF INTEREST.

SLIDE #7

ANOTHER CRITERION IS RARITY. CONNECTICUT HAS SOME OPEN SPACE ENVIRONMENTS THAT EXIST IN FEW OTHER PLACES. ONE SUCH AREA IS SHOWN IN SLIDE #7. - THIS IS A SAND PLAINS ECOSYSTEM, ONE OF SEVERAL TO BE FOUND ADJACENT TO THE QUINNIPIAC RIVER FLOODPLAIN IN CENTRAL CONNECTICUT. IT IS ONLY IN SAND PLAINS THAT WE FIND CERTAIN UNIQUE PLANTS AND ANIMALS. SUCH NATURAL ENVIRONMENTS ARE PRODUCTIVE AS WELL AS RARE. THEY PROVIDE A GREAT ELEMENT OF VARIETY. IF THEY ARE NOT PROTECTED AND PRESERVED, THEN THE TOTAL HUMAN ENVIRONMENT BECOMES THAT MUCH LESS DIVERSE. COMPARE THE NEXT SLIDES, #8 AND #9 AND DECIDE WHICH TYPE OF ENVIRONMENT YOU PREFER. (PAUSE) STOP THE RECORDER WHILE YOU VIEW SLIDES #8 AND #9.

SLIDES #8 & #9

THERE IS OFTEN CONFUSION BETWEEN THE TERMS OPEN SPACE AND NATURAL AREAS. ALL OPEN SPACES ARE NOT NATURAL areas. A natural area is a land or WATER UNIT WHERE NATURAL CONDITIONS ARE MAINTAINED OR ENCOURAGED IN SO FAR AS POSSIBLE. NATURAL CONDITIONS RESULT FROM ALLOWING ORDINARY PHYSICAL AND BIOLOGICAL PROCESSES TO OPERATE WITH A MINIMUM OF HUMAN INTERVENTION. THE NATURE CONSERVANCY IS A NATIONAL MEMBERSHIP ORGANIZATION DEVOTED WHOLLY TO THE PRESERVATION OF CRITICAL NATURAL AREAS. GUIDE SHEET # 9 CONTAINS A LIST OF SOME OF THE CRITERIA THE NATURE CONSERVANCY USES IN EVALUATING THEIR SITES. THE LIST MAY BE USEFUL TO YOU IN SELECTING NATURAL AREAS WITHIN YOUR COMMUNITY. YOU MAY WANT TO CALL UPON THE NATURE CONSERVANCY TO AID IN PRESERVING NATURAL AREAS. TURN OFF THE TAPE RECORDER WHILE YOU READ GUIDE SHEET # 9. (PAUSE)

G.S. #9

DO THE REASONS FOR PRESERVING OPEN SPACE OUTLINED ON GUIDE SHEET # 6 SEEM SIGNIFICANT TO YOU? THEY ARE SO SIGNIFICANT THAT THE CONNECTICUT PLANNING AGENCY IS TRYING TO PURCHASE ADDITIONAL OPEN SPACE AND THEREBY ENSURE ITS PRESERVATION. THEIR TASK IS DIFFICULT IN THE FACE OF EXPANDING POPULATION AND RISING LAND COSTS.

G.S. #6

BASICALLY, POPULATION GROWTH CAUSES AN INCREASED DEMAND FOR LAND. LOOK AT SLIDE # 10, COMPETITION FOR AVAILABLE LAND TODAY IS SO INTENSE THAT LAND VALUES HAVE RISEN OVER 100 PER CENT WITHIN THE PAST TEN YEARS. MOST AFFECTED, ARE FARMS AND WOODLOTS LOCATED ON THE FRINGES OF URBAN AND SUBURBAN ENVIRONMENTS, SINCE THESE AREAS ARE EASILY DEVELOPED. WHEN THESE VALUABLE LAND AREAS ARE DEVELOPED, THEY BECOME THE SOURCE OF INCREASED TAX REVENUE FOR LOCAL GOVERNMENTS.

SLIDE #10

RISING COSTS OF FARMING AND DECREASING FARM PROFITS ARE ALSO RESPONSIBLE FOR PUTTING OPEN SPACE ON THE REAL ESTATE MARKET. ALTHOUGH GROSS FARM INCOME ROSE BY $6.5 MILLION BETWEEN 1968 AND 1973 THE NET INCOME OF FARMERS DROPPED BY $12.2 MILLION, CHIEFLY BECAUSE OF INCREASED LABOR COSTS AND INFLATION. SMALL WONDER

THAT FARMERS ARE DROPPING OUT OF THE FARM PICTURE AND SELLING THEIR OPEN SPACE PROPERTIES. FARMERS HOWEVER, ARE NOT THE ONLY LOSERS, YOU AND I, AS CONCERNED CITIZENS - AND THE COMMUNITY WILL ALSO HAVE LOST A VALUABLE RESOURCE!

WHAT HAS BEEN DONE TO ALLEVIATE THIS DEPLORABLE PROBLEM? FOR ONE, THE CONNECTICUT LEGISLATURE HAS PASSED INTO LAW PUBLIC ACT 490 WHO PROVIDES TAX RELIEF TO OPEN SPACE OWNERS.

PUBLIC ACT 490 ATTEMPTS TO MAINTAIN OPEN SPACE BY TAXING THIS LAND BASED ON AN ASSESSMENT OF ITS "USE" VALUE RATHER THAN "MARKET" VALUE. UNDER USE VALUE ASSESSMENT, THE TAX BASE VALUE OF LAND IS RELATED TO ITS POTENTIAL EARNING CAPACITY WHEN USED IN BROAD LAND CLASSES UNDER THE LAW. THE LAND CLASSES ARE FARM LAND, FOREST LAND, AND OPEN SPACE. UNDER MARKET VALUE ASSESSMENT, THE TAX BASE VALUE OF LAND IS RELATED TO POTENTIAL SALES VALUE BASED UPON "COMPARABLE SALES" IN A FAIR MARKET TRANSACTION IN THE TOWN. THE FOLLOWING EXAMPLE WILL HELP EXPLAIN THE DIFFERENCE BETWEEN USE VALUE AND MARKET VALUE.

LET US USE A TWO ACRE PASTURE NEXT TO A SUBURBAN DEVELOPMENT. HOUSE LOTS IN THE AREA HAVE BEEN SELLING AT $6,000 PER ACRE. UNDER MARKET VALUE THE TWO ACRES OF PASTURE WOULD BE ASSESSED AT $12,000 OR $6,000/ACRE BECAUSE POTENTIALLY THIS IS THE VALUE OF LAND IN AN OPEN MARKET. BY USE VALUE, THE SAME PARCEL WOULD BE ASSESSED AT $250/ACRE TO $500/ACRE SINCE THIS IS THE VALUE THE FARMER WOULD RECEIVE FROM UTILIZING THE PASTURE. IT IS OBVIOUS THAT IN THE SAME TOWN THE TAXES BASED ON USE VALUE ASSESSMENT WOULD BE LOWER THAN UNDER MARKET VALUE ASSESSMENT.

THIS WAS THE PURPOSE OF THE ACT. LEGISLATORS REASONED THAT IF TAXES WERE LOWER ON FARM, FOREST, AND OPEN SPACE AREAS A LAND OWNER WOULD BE MORE LIKELY TO MAINTAIN THEM IN THAT CONDITION AND THEREFORE MAINTAIN A COMMUNITY ASSET.

GUIDE SHEET # 10 PROVIDES MORE DETAILS ON PUBLIC ACT 490. IT POINTS OUT PROBLEMS WITH THE LAW THAT HAVE BEEN CORRECTED BY SUBSEQUENT LEGISLATION. TURN OFF THE RECORDER WHILE YOU READ GUIDE SHEET # 10. G.S. #10

PUBLIC ACT 490 IS ONLY ONE METHOD OF ENCOURAGING THE MAINTENANCE OF ADEQUATE OPEN SPACE. CONTINUED EFFORTS BY BOTH THE PUBLIC AND PRIVATE SECTOR ARE NECESSARY TO ADEQUATELY PLAN FOR AND MAINTAIN OPEN SPACE AREAS. ON GUIDE SHEET #11, WE HAVE LISTED THE PUBLIC AND PRIVATE AGENCIES INVOLVED IN OPEN SPACE AQUISITION AND MANAGEMENT. IF YOU ARE INTERESTED IN THE ISSUE OF PRESERVING OR MANAGING OPEN SPACE WE SUGGEST YOU CONTACT THOSE AGENCIES LISTED ON GUIDE SHEET # 11, WHICH CAN AID YOU IN YOUR WORK . . . G.S. #11

THERE ARE TWO MAJOR METHODS OF LAND PROTECTION: REGULATION TO PROTECT OPEN SPACE OR AQUISITION OF INTERESTS IN LAND. WITHIN THE REGULATION OPTIONS, THERE ARE THREE SUBSECTIONS: THE FIRST IS THE POLICE POWER OF GOVERNMENT. REGULATIONS OF THIS TYPE INCLUDE ZONING OR SUBDIVISION CONTROLS. THE SECOND SUBSECTION INVOLVES

THE POWERS OF TAXATION SUCH AS PUBLIC ACT 490 OR USE VALUE ASSESSMENT. AND FINALLY, REGULATIONS THAT CONTROL DEVELOPERS SUCH AS AIR AND WATER QUALITY ACTS, SEWER MORATORIUM, OR CONSUMER LEGISLATION.

AQUISITION OF INTERESTS IN LAND CAN INVOLVE THE PURCHASE, LEASE OR GIFT OF LAND OR LESS THAN FULL CONTROL CAN BE OBTAINED BY EASEMENTS OR THE PURCHASE OF CERTAIN RIGHTS IN THE PROPERTY SUCH AS AIR, MINERAL, OR DEVELOPMENT RIGHTS.

INFORMATION ABOUT METHODS OF OPEN SPACE AQUISITION AND PRESERVATION IS AVAILABLE IN TWO FORMS IN THIS UNIT. GUIDE SHEET #12 PROVIDES A SUMMARY OF VARIOUS G.S. #12 METHODS OF REGULATING OPEN SPACE AND OUTLINES ALTERNATIVE PROCEDURES FOR ACQUIRINNG INTERESTS IN LAND. ALSO INCLUDED IN THE LAND USE DECISION MAKING KIT IS A PAMPHLET ENTITLED LAND, MOST ENDURING GIFT PREPARED BY THE CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION. THIS PAMPHLET PROVIDES PROSPECTIVE DONORS OF LAND AND WATER WITH INFORMATION ON THE MECHANICS OF TRANSFERRING OWNERSHIP OR RIGHTS IN LAND TO A PUBLIC OR PRIVATE ORGANIZATION. THE PAMPHLET EXPLAINS THE OPTIONS AND ALTERNATIVE METHODS OF ACCOMPLISHING THIS GOAL. WE SUGGEST THAT YOU READ THIS PAMPHLET IF YOU ARE IN A POSITION TO MAKE A DONATION OF LAND TO A PUBLIC OR PRIVATE SLIDE #1 LAND TRUST OR KNOW SOMEONE WHO MIGHT BE SO INCLINED. Some land in a land trust is shown in slide #11.

IF MORE INFORMATION BEYOND THE GUIDE SHEET #12 AND THE PAMPHLET ARE NECESSARY, THERE ARE SOME EXCELLENT SOURCES IN THE BIBLIOGRAPHY WHICH PROVIDE INFORMATION ON THIS TOPIC. AS YOU WILL RECALL, GUIDE SHEET # 11 CONTAINS A LIST OF PUBLIC AND PRIVATE AGENCIES INVOLVED IN THE AQUISITION AND MAINTENANCE OF OPEN SPACE. IF WILL BE USEFUL REFERENCE TO REFER TO IF YOU KNOW OF A PARCEL OF LAND IN YOUR COMMUNITY OR STATE THAT SHOULD BE PROTECTED AS PERMANENT OPEN SPACE.

HOW MAY YOU AND YOUR FRIENDS HELP ACQUIRE AND PRESERVE OPEN SPACE FOR YOUR COMMUNITY? INCLUDED IN THIS UNIT IS A BOOKLET ENTITLED, PRIORITIES IN OPEN SPACE PLANNING AND ACQUISITION, WHICH YOU OUGHT TO READ BEFORE YOU BEGIN YOUR OPEN SPACE CAMPAIGN. The booklet is included as guide sheet #13. G.S. #13

LET US OUTLINE SEVERAL OF THE BASIC IDEAS CONCERNING OPEN SPACE PLANNING. G.S. #14
An outline of strategies is presented on guide sheet #14. Use this as a reference as we continue our discussion.

FIRST, DETERMINE WHAT YOUR CAMPAIGN WILL BE, THAT IS, JUST WHAT OPEN SPACE DO YOU FEEL OUGHT TO BE ACQUIRED AND PRESERVED? PERHAPS YOU HAVE READ ABOUT SOME MARSH FILL DEVELOPMENT TO TAKE PLACE IN YOUR AREA. OR PERHAPS A HISTORICAL BUILDING IS SCHEDULED TO BE DEMOLISHED TO PROVIDE A CITY PARKING LOT. IN SHORT, RECOGNIZE A PARTICULAR GOAL - IT WILL THEN BE MUCH EASIER TO GENERATE ENTHUSIASM AND SUPPORT FOR YOUR CAUSE.

SECOND, YOU MUST BECOME KNOWLEDGEABLE ABOUT YOUR SUBJECT. UNFORTUNATELY, ENTHUSIASM AND SUPPORT COUNT FOR LITTLE UNLESS YOU CAN SHOW THAT YOU ARE WELL INFORMED ABOUT THE OPEN SPACE PRESERVATION ISSUE. IN SHORT, KNOW WHAT YOU ARE

TALKING ABOUT. THIS UNDOUBTEDLY MEANS THE ESTABLISHMENT OF A RIGOROUS PROGRAM OF SELF-EDUCATION FOR YOU AND YOUR GROUP, YOU WILL WANT TO DRAW UPON MANY AVAILABLE SOURCES FOR YOUR INFORMATION. YOU WILL HAVE TO BE WELL INFORMED ABOUT PRINCIPLES OF OPEN SPACE PRESERVATION AND MANAGEMENT AND LAND USE IN GENERAL. NEWSPAPERS PROVIDE AN INITIAL STARTING POINT - NOT JUST ONE, BUT SEVERAL, PREFERABLY THOSE WHICH OFFER A VARIETY OF CONTRASTING VIEWPOINTS. NEXT OBTAIN BOOKLETS AND PAMPHLETS PUT OUT BY CONSERVATION AGENCIES. ALSO INQUIRE AT LOCAL (AND NATIONAL) BUSINESS AND INDUSTRIES TO OBTAIN MATERIALS EXPRESSING THEIR VIEWPOINTS. AFTER YOUR BASIC PERIOD OF FAMILIARIZATION, BECOME AQUAINTED WITH THE MORE TECHNICAL BOOKS AND RESEARCH JOURNALS WHICH MAY BE READ IN YOUR LOCAL LIBRARY. A BASIC BIBLIOGRAPHY OF READING MATERIALS CAN BE FOUND AT THE END OF THE GUIDE SHEETS FOR THIS UNIT. AFTER DEVELOPING A READING BACKGROUND, YOU MAY FIND A GROUP DISCUSSION TO BE A PROFITABLE MEANS OF ANALYZING AND SYNTHESIZING THE INFORMATION OBTAINED.

THIRD, WRITE AND OBTAIN COPIES OF REGIONAL, STATE AND FEDERAL LAWS WHICH WILL AFFECT YOUR PROJECT. ASK YOUR POLITICAL REPRESENTATIVE HOW THESE LAWS MAY AFFECT YOUR PROJECT.

FOURTH, OBTAIN AS MUCH FACTUAL INFORMATION ABOUT THE SPECIFIC OPEN SPACE AREA WHICH YOU ARE INTERESTED IN. THIS IS WHERE FACTS ARE IMPORTANT, BECAUSE THEY WILL TEND TO INFLUENCE YOUR PUBLIC. TO FIND THIS INFORMATION, STUDY SURVEY MAPS AND AERIAL PHOTOS. ENLIST THE AID OF LOCAL CONSERVATION OFFICERS AND BIOLOGISTS TO MAKE A BIOLOGICAL INVENTORY OF YOUR AREA. REMEMBER THAT THE LOCAL HISTORICAL SOCIETY MAY PROVIDE INTERESTING AND INVALUABLE INFORMATION ABOUT YOUR SITE..

AFTER YOU HAVE OBTAINED THE NEEDED BACKGROUND INFORMATION, YOU WILL NEED TO WRITE A PROPOSAL FOR LAND PRESERVATION IN A CLEAR, FACTUAL MANNER. BE SURE TO INCLUDE A MAJOR SECTION ON BENEFITS TO BE DERIVED FROM THE PROJECT. THE PUBLIC, IS INTERESTED IN THE BENEFITS WHICH THEY, AND THEIR CHILDREN, WILL DIRECTLY DERIVE BY ENDORSING YOUR PROJECT.

NOW TAKE YOUR PROJECT TO THE PUBLIC FOR ITS APPROVAL. THIS MEANS BRINGING IT TO THE PUBLIC'S ATTENTION BY RADIO, TV AND NEWSPAPER COVERAGE. HOLD LOCAL MEETINGS TO AIR YOUR PROPOSAL AND DRUM UP SUPPORT AT THE SAME TIME. AFTER YOUR CAMPAIGN HAS GAINED MOMENTUM, APPROACH POLITITIANS FOR THEIR ENDORSEMENTS. POLITICAL LEADERS WILL READILY SUPPORT PUBLIC INTEREST PROJECTS, PARTICULARLY IF THEY DEAL WITH NON-PARTISAN ISSUES. DON'T NEGLECT TO OBTAIN CONVINCING EVIDENCE OF PUBLIC SUPPORT. PETITION CAMPAIGNS FOR EXAMPLE, WILL VERY FORCEFULLY SHOW THE INTEREST OF THE PUBLIC IN YOUR PROJECT.

PRESERVATION AND MANAGEMENT OF OPEN SPACE IS A POSITIVE GOAL FOR COMMUNITIES TO WORK TOWARD.

FOCUS ATTENTION ON THE POSITIVE GOALS AND LONG TERM BENEFITS. A REALISTIC, BROAD BASED APPROACH TO OPEN SPACE PRESERVATION AND MANAGEMENT CAN BE UNIFYING EXPERIENCE FOR A COMMUNITY. GOOD LUCK IN YOUR EFFORTS!